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PALYNOLOGY OF THE DUNVEGAN FORMATION IN TYPE
AREA, ON PEACE RIVER, ALBERTA

BY

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Palynology of the Dunvegan Formation, in type area, on Peace River, Alberta", submitted by Bindraban Thusu, M.Sc., in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The Upper Cretaceous Dunvegan Formation palynological assemblage includes 18 species of microplankton belonging to 10 genera, 94 species of spores and pollen belonging to 54 genera and 8 species of megaspores belonging to 6 genera. This microflora is described and figured. Some of the forms appear to be new. The microflora can be subdivided into six assemblages.

1. Marine microplankton.
2. Angiosperm assemblage, including monocotyledons and dicotyledons.
3. Cycadalean assemblage.
4. Coniferalean assemblage.
5. Ephedralean assemblage.
6. Fern assemblage.

The presence of marine microplankton are indicative of sporadic marine depositional environment. The six assemblages indicate a warm temperate to subtropical climate during Dunvegan times. The intercontinental and intracontinental microfloral comparison, based on angiospermous pollen shows a close similarity with Cenomanian microflora of the Atlantic coastal region and of Portugal.



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CHAPTER ONE - INTRODUCTION

This thesis is presented at the time when palynology celebrates half a century of its existence as a separate branch of natural science. Actually during the late 1940's there was increasingly frequent reference in the literature to the application of this scientific discipline in solving stratigraphic and paleoecological problems. The successful utilization of palynology in stratigraphic work of petroleum geology has given modern palynology its greatest impetus.

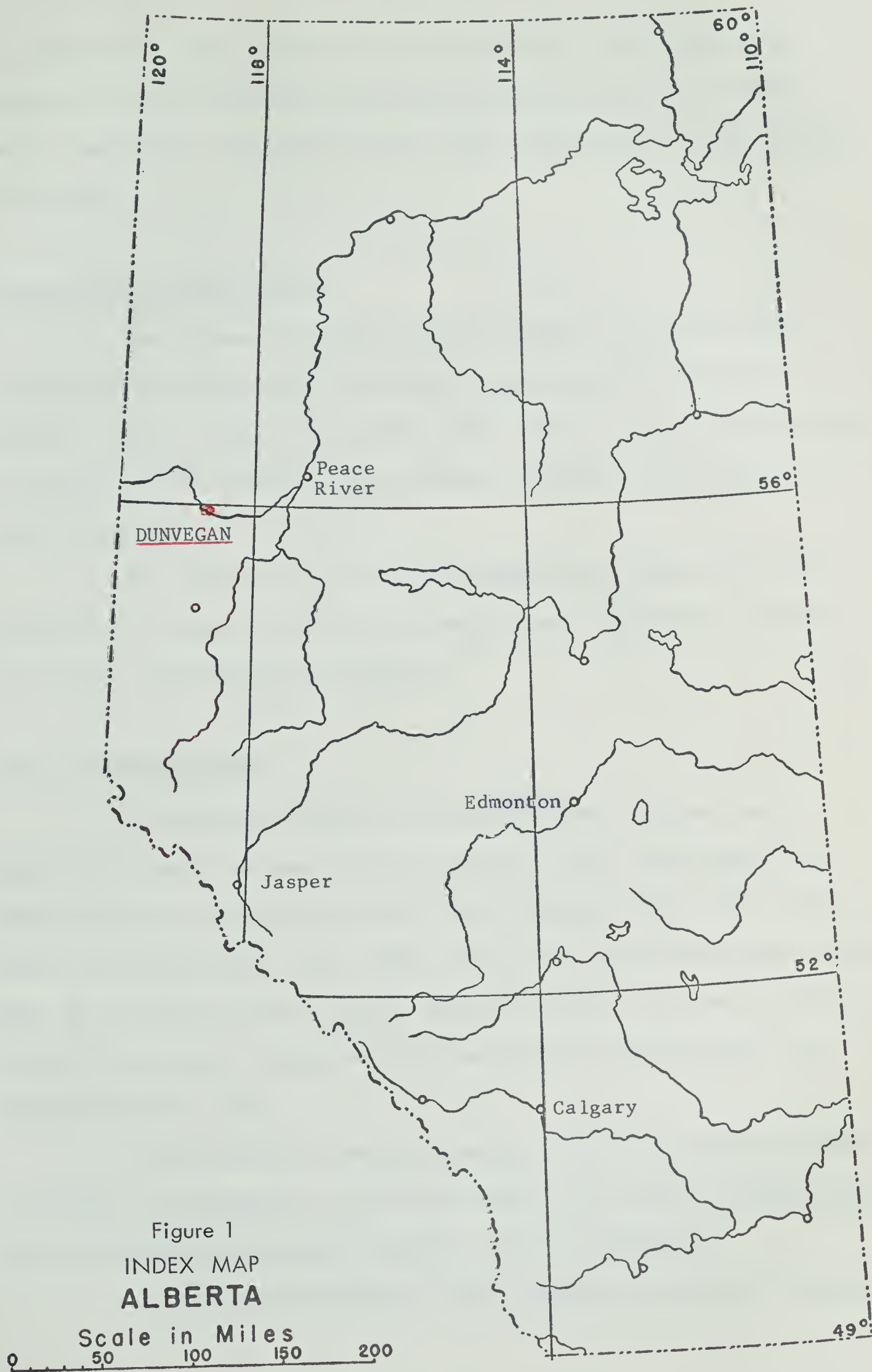
In Western Canada, significant contributions to Mesozoic palynology did not start until early 1960. The Dunvegan Formation of fresh to brackish origin and of wide extent in north-eastern British Columbia and northern Alberta, provides an interesting target for palynological investigations. Marine microplankton included in this palynological assemblage added additional interest to the present study because the offshore deltaic portion of parts of the Dunvegan Formation has already yielded marine megafaunas interfingering with the fresh water faunas and land plants.

Purpose of the Project

The principal purpose of this study is to describe the microfloral assemblage of the Dunvegan Formation of the type area, on the Peace River at Dunvegan, Alberta.

Samples from the type section at Dunvegan were processed for microspores, pollen, marine microplankton and megaspores.

From the microfloral evidence the following aspects are considered, viz: the plant groups found in the Dunvegan Flora; paleoecology;



the microfloral change from Lower Cretaceous flora; correlation and comparison with the equivalent microflora-bearing formations in North America and Europe; comparison between plant megafossils and microfossils in the area.

Location of the Material Used

The Dunvegan Formation samples studied in this work were collected at the "type area" at Dunvegan Crossing close to bridge on Highway. (Lat. $55^{\circ} 56'N.$, Long. $118^{\circ} 36'W.$; Twp. 80, Rge. 4, W6 Meridian). The position of the samples in the vertical section of the formation is shown in fig. 2.

The samples treated for investigation are mainly shales and siltstones, as coarser beds yield too restricted a microfloral spectrum for critical palynological assessment.

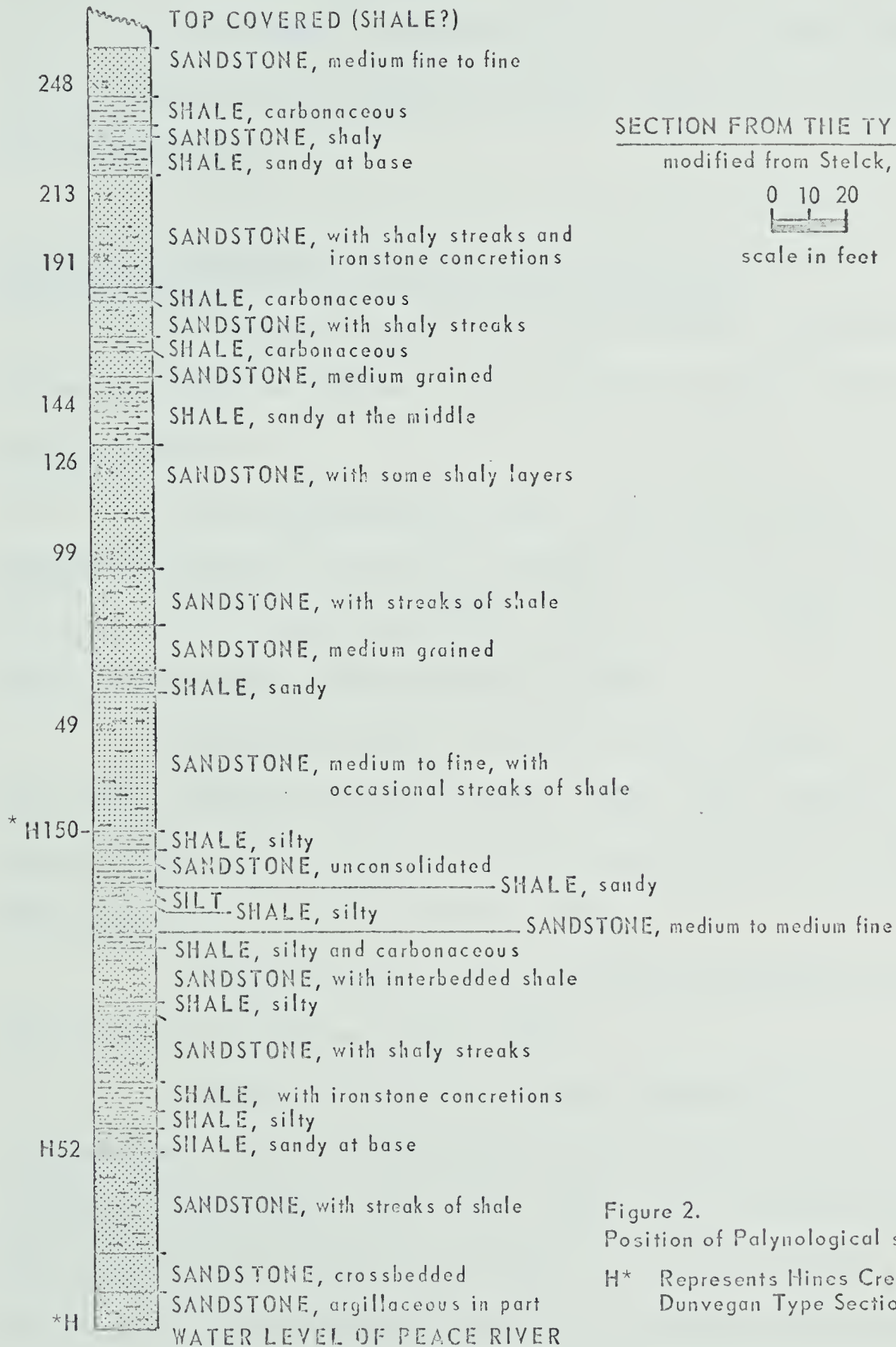
Review of Previous Work

The Dunvegan Formation of Late Cretaceous age has been subject of numerous palaeontological studies. Among them significant contributions on megafauna have been made by McLearn (1919, 1926, 1945), Warren and Stelck (1940, 1955, 1958), Irish (1951) and Thorsteinsson (1952). While the studies by Stelck (1955), Stelck and Wall (1955) and Stelck, et. al. (1958) are mainly micropaleontological and the megafloora has been described by Bell (1963).

These detailed investigations have added much to our knowledge of Dunvegan biostratigraphy and palaeoecology, but to date no palynological studies dealing with Dunvegan Formation have been published.

Beveridge and Folinsbee (1956) studied heavy mineral assemblages

DUNVEGAN FORMATION



of the formation. The purpose of this study was to connect Mesozoic and Cenozoic sedimentary rocks of the Alberta basin with the batholithic intrusives of the Cordillera.

Tater (1964) studied sandstones of the Dunvegan Formation from the type area with respect to texture, composition, and K-Ar dates from K-feldspars.

Review of Pertinent Palynological Work in Cretaceous

In northern Alberta and British Columbia, palynological studies on Cretaceous sediments have been made by Rouse (1959), and Jansonius (1962).

A few palynological studies of American lowermost Upper Cretaceous deposits (to which the Dunvegan Formation is assigned) include the works of Groot and Penny (1960), Groot, et. al. (1962), Pierce (1961), Leopold and Pakiser (1964) and Hedlund (1966).

Palynological work on the Late Upper Cretaceous includes Ames (1950), Radforth and Rouse (1954), Rouse (1959), Anderson (1960), Clarke (1963), Hills and Weiner (1965), Srivastava (1965, 1966), Drugg (1966) Leffungwell (1966) and Rouse (1966).

A detailed study of Lower Cretaceous microflora include the works of Pocock (1962) and Singh (1964).

Intensive studies of Cretaceous palynology have been carried out since 1951. This is particularly true of Russia, Europe and Australia. In Russia, Bolkhovitina (1953, 1956, 1959, 1961) and Maljavikina (1949, 1958) have carried out extensive studies on Mesozoic deposits. Voyevodera and Khaikina (1960) described microflora of the Upper Cretaceous in north-eastern U.S.S.R. In Germany Thiergart (1949) studied microflora from

Triassic to Tertiary. Delcourt and Sprumont (1955, 1957) described spores and pollen of Europe.

In Australia and New Zealand, Couper (1953, 1960), Balme (1957), Cookson and Dettmann (1958, 1959, a, b, c, d, 1961), Cookson (1961), and Dettmann (1959, 1963) have presented excellent publications on Cretaceous palynology.

Megaspore study of Cretaceous deposits in Europe and Australia include the works of Dijkstra (1951), Hughes (1955), Cookson and Dettmann (1958, a, b, 1959).

Pertinent studies of microplankton include the works of Deflandre (1936, 1937), Gocht (1957, 1959) and Eisenack (1958) in Europe. Cookson and Eisenack (1958, 1960, 1961, 1962) studied Cretaceous microplankton from Australia.

CHAPTER TWO - STRATIGRAPHY

Dawson (1881) gave the formation name "Dunvegan" for what he called the "lower sandstones and shales of the Pine River and parts of Peace River Valley". Two type sections of the Dunvegan Formation were designated - one on the Peace River (at Dunvegan, Alberta) and another on the Pine River (at East Pine, British Columbia). The Pine River section includes additional stratigraphic intervals both above and below. The type area is usually considered to be at Dunvegan, Alberta, on the Peace River (Stelck 1962).

Distribution

The Dunvegan Formation has an extensive distribution in northwestern Alberta and northeastern British Columbia. The formation is well developed in the Fort St. John and Peace River areas. To the north the formation has been traced northward to Liard River (Stott 1963) and Tetsa Valley (Williams 1944). To the south McLearn and Henderson (1944), identified the formation at Monkman Pass while the most southernly known exposures were reported by Irish (1965) in the valley of Solomon Creek.

To the east correlatives of the formation were traced by Stelck et. al. (1958) to Athabasca River. Williams (1944) considered the formation of conglomerate and sandstone on Table, Steamboat and Teepee mountains, west of Fort Nelson, equivalent in age to Dunvegan. Similarly Stott (1963) has described equivalents of the Dunvegan Formation from the Bighorn River.

A detailed account of subsurface distribution of the

Dunvegan Formation was given by Gleddie (1954) and Burke (1963). A well defined stratigraphic section was drawn by Williams and Burk (1964) showing the subsurface distribution of the Dunvegan Formation from west to east, Alberta (fig. 3).

Lithology

The strata of the Dunvegan formation consists of alternating sandstones and shales with all gradations between the two. In general the lower beds are mostly light coloured, cross bedded, massive sandstones, while the upper beds are generally thin bedded sandstones and arenaceous shale strata. In the northwest and west, grits and conglomerates predominate, which increase in coarseness to the west. Flat ironstone concretions, plant stems and leaf imprints, ripple markings and worm borings are common. The sands as well as shales generally show carbonaceous matter. Coal seams are reported up to 23 inches in thickness in various localities. Lenses of limestone showing cone-in-cone structure were reported by Williams and Bock (1932, p. 212). The sediments are in part of non-marine origin and in part marine or brackish water origin as indicated by paleontological studies.

Thickness and Geometry

In the valley of Solomon Creek, the most southerly known exposure of 'Dunvegan' consists of a single bed of silty sandstone about 20 feet thick. To the northwest the formation thickens rapidly. Irish (1965) reported exposures ranging from 350-500 feet thick on a south flowing tributary of Cowlick Creek (east of Sulphur River). In general thickness varies from about 1200 feet in the northwest (Pine River section)

to 300 feet in the southeast. To the southeast the formation is gradually replaced by siltstone and shale. Local changes in thickness of the Dunvegan Formation are due to the lenticular nature of the sediments.

Lower Contact of the Formation

The lower contact of the Dunvegan Formation lies conformably above the Fort St. John Group. Wherever a basal contact is exposed, a transitional zone is present. This transitional zone consists of silty shale with intercalated thin sandstone beds. This is usually overlain by 30 feet of quartzitic sandstone (Irish 1965). For the purpose of field mapping Irish (1965) considers the base of the formation to be at the base of the sandstone. Stott (1963) draws the base of the formation at the base of the lowest siltstone.

On paleontological evidence, Stelck et. al. (1958) mark the base of the formation on the Smoky River near the mouth of Racing Creek by the presence of the fossil Pleurobema dowlingi McLearn, and further state that the formation near Fort St. John is stratigraphically lower and carries the fossil Pleurobema cruiserensis Warren and Stelck, (1958).

Upper Contact of the Formation

The Dunvegan Formation is overlain by the Kaskapau Formation. The contact is conformable and transitional. This contact has been observed at a very few localities (Stott, 1963). However, the contact is drawn at the base of rusty, silty shales that overlie massive siltstone or sandstone.

On palaeontological evidence Crickmay (1944) defined the top of the formation at about the stratigraphic position of Inoceramus

dunveganensis McLearn. However, because of the transitional nature of beds between the Dunvegan Formation and the Kaskapau Formation, it is sometimes advantageous to mark the contact on the basis of fossil change than on gross lithology.

Depositional Environment

The depositional history of the Dunvegan Formation which apparently is responsible for the four fold division of the formation is well exposed in Beaton River section. This section reveals the following divisions (Stelck, et. al. 1955).

1. An upper plant bearing - deltaic sequence 400 feet thick.
2. A middle conglomeratic arkosic member 300 feet thick.
3. A brackish lower member - 200 feet thick.
4. A basal sand member - 100 feet thick.

According to Stelck et. al. (1955) the basal sand member and brackish lower member represents the sanding up of the Cruiser Sea. The arkosic sand member introduces the fluvial phase of the Dunvegan and marks the expulsion of the sea from the Fort St. John area.

The arkosic member is known to rest at places with an erosional unconformity upon the brackish member, although there is no indication of this feature on Beaton River itself. This erosional unconformity upon the brackish member is prevalent in the area to the west and northwest where conglomerates become common. Beveridge and Folinsbee (1956) have proposed that the arkosic member actually represents the unroofing of the batholiths in northern British Columbia. This observation is supported by the very low feldspathic content in the earlier

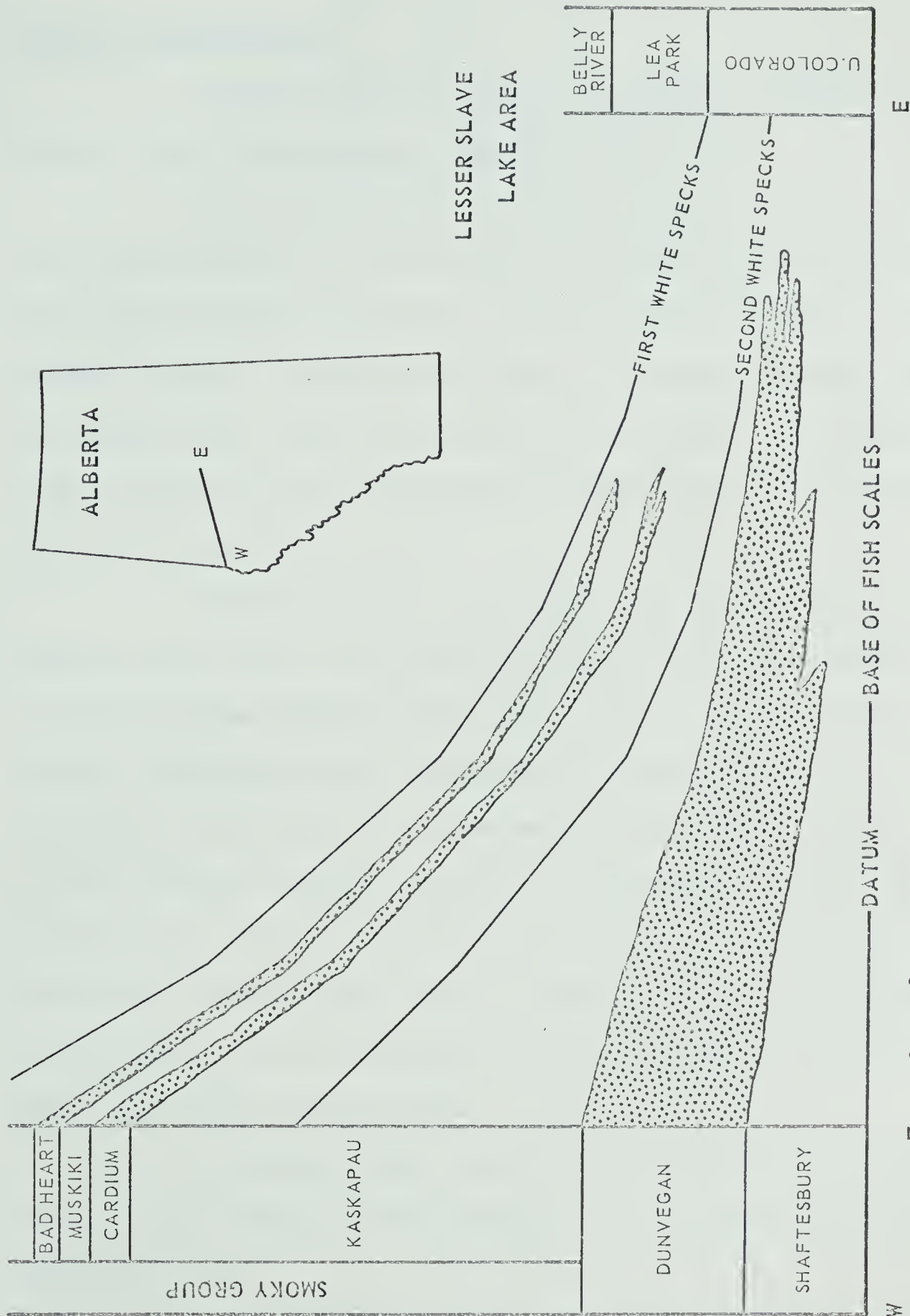


Figure 3. Stratigraphic section showing sub surface distribution of the Dunvegan Formation, west to east Alberta (Modified from Williams and Burk, 1964)

sands within the Fort St. John area.

Regional Consideration

A regional consideration of the Dunvegan Formation may be outlined here, in the words of Stelck and Wall (1955).

"The Dunvegan Sands in Alberta represent the outer margins of a delta built out as a broad apron skirting an upland centering on the southern Mackenzie mountains, and the Cassiar mountains of northern British Columbia. A major river system, apparently draining through the general Liard Plateau area, spilled arkosic beds into northeastern British Columbia with the more conglomeratic phases present northward towards the Liard gap.

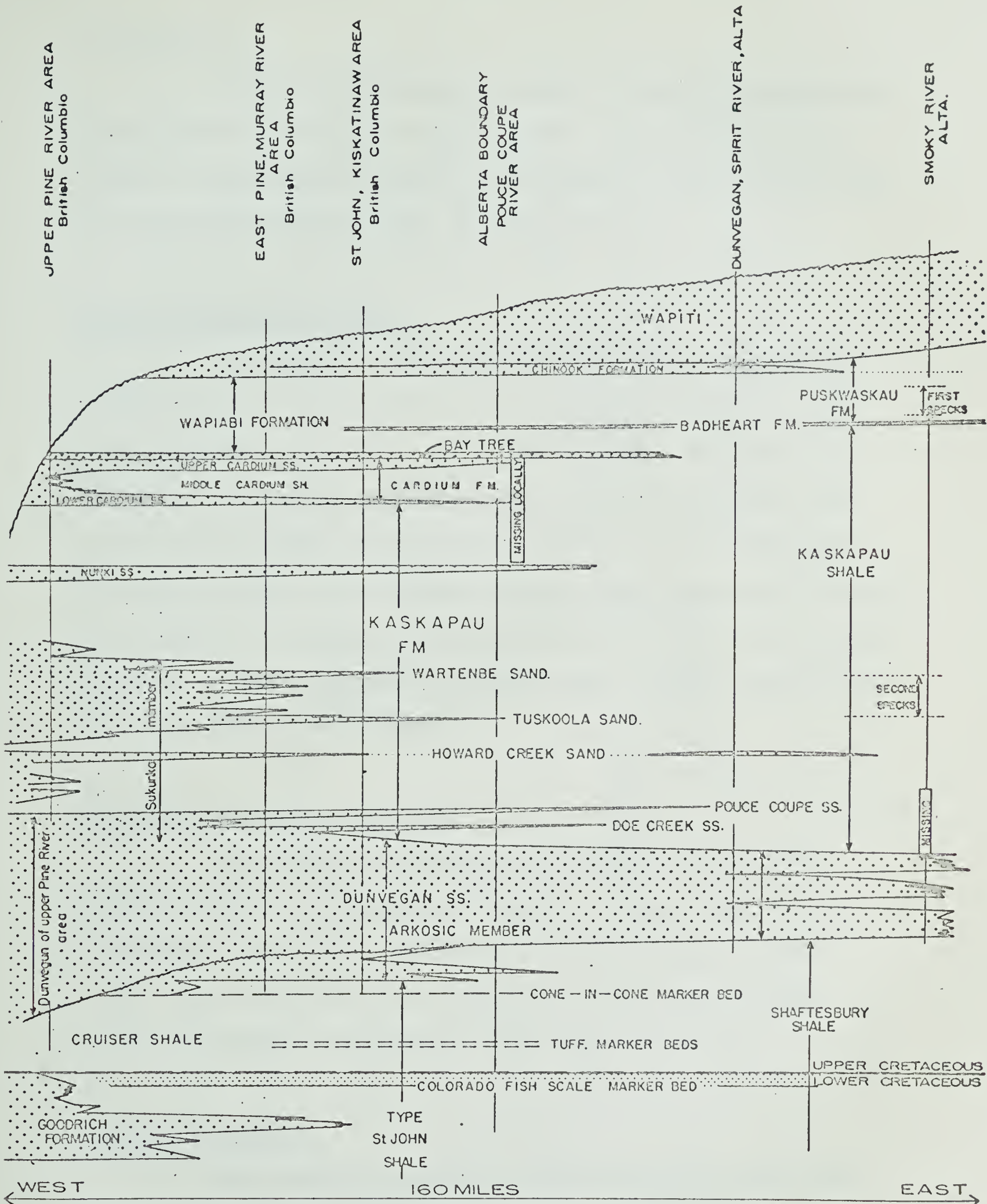
Continued uplift of the source area involved the upper reaches of the delta in the erosional cycle and the later sandy beds of the early Late Cretaceous find their source, in part, in the reworked Dunvegan deltaic material. The implied tilting moved the late Cenomanian shoreline southeastward and, consequently, the farthest southward expression of these "deltaic" Dunvegan deposits is considerably younger than the main arkosic beds of northeastern British Columbia. In offshore facies, only the latest Cenomanian beds appear in sandy phase, and the outermost latest margins of the "Dunvegan" delta carry marine (?) coal seams interbedded with beds carrying oysters"

The Dunvegan delta wedges into the Colorado sea deposits and the delta itself and the formation is not recognized beyond the Athabasca River.

The relationship of the marine shales and deltaic sandy tongues of the Cenomanian beds are shown by Stelck (1962) in schematic



Fig 4. Stratigraphic Terminology of early Upper Cretaceous Rocks in Parts of Northeastern British - Columbia and Northwestern Alberta.
(After Irish 1965)



Diagrammatic sketch only—not to scale

P.D.

Fig.5 SCHEMATIC DIAGRAM TO ILLUSTRATE FACIES CHANGES IN UPPER CRETACEOUS STRATA, PEACE RIVER AREA

form (fig. 5).

The plant bearing deltaic member is transitional and inter-fingers with the overlying Kaskapau shales. However, arkosic sands similar to those associated with the conglomeratic member may be found filling fluvial channels in the uppermost Dunvegan.

Age of the Dunvegan Formation

The study of marine invertebrates by Warren and Stelck, (1940); Stelck, et. al. (1955) has left little doubt about the early Upper Cretaceous (Cenomanian) age of the formation. The Lower/Upper Cenomanian boundary was chosen by Stelck et. al. (1955) at the base of the arkosic member of the Dunvegan Formation, on the argument that the arkosic member marks a natural division within the Dunvegan Formation with respect to provenance, depositional environment and paleontological content. An Upper Cretaceous correlation chart modified from Williams and Burk (1964) appears as Table I.

Regional Stratigraphic Succession

New evidence accumulated in recent years gives a clear understanding of the relationship between the southern and northern stratigraphic succession. The diagram (fig. 4) proposed by Irish (1965) shows the changes in stratigraphy and terminology of Upper Cretaceous formation from Athabasca River to Peace River.

Regional Correlation

The regional correlation of the Dunvegan type area on the basis of paleontology is attempted:-

STAGE	SOUTH WESTERN ALBERTA FOOTHILLS	CENTRAL ALBERTA FOOTHILLS	CENTRAL & SOUTHERN ALBERTA	EASTERN ALBERTA	N.W. ALBERTA PLAINS & FOOTHILLS	N.E. BRITISH COLUMBIA FOOTHILLS	LIARD RIVER	WESTERN U.S.A.
MAESTRICHTIAN	LOWER WILLOW CK	BRAZEAU	EDMONTON	BEARPAW	WAPITI	WAPITI	WAPITI	HELL CREEK
	ST. MARY RIVER							FOX HILLS
CAMPANIAN	Bearpaw	ALBERTA	BEARPAW	Belly River	WAPITI	WAPITI	WAPITI	UNAMED
	Belly River		OLDMAN FORE MOST					
SANTONIAN	ALBERTA	WAPIABI	LEA PARK	Lea Park	SMOKY	SMOKY	KOTANEE LEE	MITTEN
CONIACIAN								GAMMON
TURONIAN	CARDIUM	CARDIUM	First Specks	U. COLORADO	Puskwaskau	Puskwaskau	?	NIORARA
	BLACK STONE							
CENOMANIAN	ALBERTA	WAPIABI	Second Specks	Fish Scales	DUNVEGAN	DUNVEGAN	FT. NELSON	CARLILE
								GREEN HORN
ALBIAN	ALBERTA	WAPIABI	Fish Scales	Fish Scales	SHAFTES BURY	CRUISER	SULLY	BELLE FOURCHE
								MOWRY

TABLE 1. Stratigraphic terminology of Upper Cretaceous rocks in northeastern British Columbia and Alberta (modified from Williams and Burk, 1964)

Pleurobema dowlingi (McLearn) is found in the lower Dunvegan sandstone throughout the Peace River and Smoky River area. The fossil flora found in the beds carrying Pleurobema dowlingi McLearn is very close to the flora described from the top of the Aspen Shale in Wyoming. Brachidontes cf. B. fulpensis Stephenson is described from the lower Dunvegan in the Peace River area of Alberta where the brackish margin of the Dunvegan delta replaces the fresh water facies. Brachidontes fulpensis Stephenson was originally described from the Cenomanian Woodbine Formation of Texas.

Inoceramus athabaskensis McLearn which occurs throughout the foothills of Alberta north of Athabasca River is almost contemporaneous with Inoceramus dunvegansis McLearn, fauna from the topmost beds of the Dunvegan sandstone on the Peace River at Dunvegan crossing. This Inoceramus athabaskensis McLearn, provides a correlation with the Woodbine Formation of Texas as the Euless member of the latter formation carries, Inoceramus eulessanus Stephenson, a form found with Inoceramus athabaskensis McLearn in the Lower Dunvegan Formation of the Alberta foothills.

Megaflora of the Dunvegan Formation

Megaflora remains in a dominantly sandstone formation, like the "Dunvegan" ordinarily would not be expected to yield floras adequate for refined age determination or intercontinental correlation. Such assemblages are meagre representatives of the total floras of the time within the region, after transportation and burial in a porous clastic medium. Under such circumstances the study of pollen and spores furnishes

a much fuller representation of the floras.

The megaflora of the Dunvegan Formation was studied in detail by Bell (1963). The megaflora is dominantly composed of angiosperms, however, pteridophytes and gymnospermous plants are also common.

According to Bell (1963) the Dunvegan flora (Cenomanian) is well differentiated from the Albian flora. The only exceptions are two angiospermous plants. Trochodendroides potomacensis and Menispermities which occur in both the Dunvegan and the Albian (Blairmore Group) floras.

An outline of the flora described by Bell (1953) is given below:-

DUNVEGAN FLORA

Filicales

Onychiopsis sp. cf. O. psilotoides (Stokes and Webb)

Saccoloma? sp.

Tapeinidium? undulatum (Hall) (Knowlton)

Sphenopteris stricta (Newberry)

Sphenopteris (Dennstaedtia?) burlingi Bell

?Cladophlebis arctica (Heer)

Cladophlebis sp. cf. C. virginensis Fontaine

Cladophlebis simplicima Bell

Filicites sp.

Lycopodiales

Isoetites horridus (Dawson) Brown

Gymnospermae

Baiera sp. cf. B. furcata (Lindley and Hutton) Braun

Ginkgo sp.

Pseudocycas unjiga (Dawson)

Pseudoctenis latipennis (Heer) Seward

Dammarites robinsi (Dawson) Bell

Brachyphyllum (Athrotaxites?) douglasi Bell

Torreyites dicksonioides (Dawson)

Cephalotaxopsis heterophylla Hollick

Sequoiites sp. cf. Geinitzia formosa Heer

Metasequoia cuneata (Newberry)

Elatocladus sp. cf. Sequoia major Velenovsky and Viniklar

Widdringtonites reichii (Ettingshausen) Heer

Protophyllocladus polymorpha (Lesquereux)

Angiospermae

Dryophyllum gracile Debey

Ficus glascoeana Lesquereux

Ficus daphnogenoides (Heer) Berry

Ficus? sp.

Nymphaeites exemplaris Hollick

Castaliites cf. C. cordatus Hollick

Palaeonuphar nordenskioldi (Heer)

Trochodendroides (Cercidiphyllum?) potomacensis (Ward)

Menispermities reniformis Dawson

Magnolia magnifica Dawson

Magnolia boulayana Lesquereux

Magnolia lacoeana Lesquereux

Magnolia rhamnoides Bell

Magnolia hollicki Berry

Liriodendron giganteum Lesquereux

Laurophyllum flexuosum (Newberry)

Cinnamomum heeri Lesquereux

Platanus williamsi Bell

Platanus newberryana Heer

Platanus latiloba Newberry

Platanus affinis Lesquereux

Credneria macrophylla Heer

Credneria truncatodenticulata Bell

Ampelophyllites attenuatus (Lesquereux) Knowlton

Protophyllum multinerve? Lesquereux

Pseudoprotophyllum boreale (Dawson) Hollick

Aspidiophyllum dentatum? Lesquereux

Pseudoaspidiophyllum latifolium Hollick

Hymenaea fayettensis Berry

Bauhinia? cretacea? Newberry

Dalbergia hyperborea Heer

Leguminosites spatulatus Bell

Sterculia aperta? Lesquereux

Araliaephyllum rotundiloba (Newberry) Fritel

Araliaephyllum groenlandica? Heer

Aralia sp. cf. A. parvidens Hollick

Hedera sp. cf. H. cretacea Lesquereux

Andromeda? spatula Bell

Diospyros lesquereuxi Knowlton and Cockerell

Dicotylophyllum sp. A. Bell

Dicotylophyllum sp. B. Bell

Carpites sp.

The "Dunvegan" flora has five species common to the "Woodbine" flora, ten species to the Magothy flora, twelve species to the "Tuscaloosa" and "Raritan" floras (see Table 2). On the other hand four species are common to the "Dunvegan", "Magothy" and "Woodbine" floras.

The Dakota Formation has a diachronous stratigraphic range (M. Albian - Turonian). Therefore comparison of "Dakota" flora with Dunvegan is somewhat meaningless. However, in this connection Lesquereux (1893) collected a small number of fossil leaf impressions from the New Ulma area in Minnesota, which he referred to as a "Dakota" flora. Subsequently Pierce (1961) collected his samples for palynological studies from the same area and assigned earliest Late Cretaceous age to the formation.

The Woodbine Formation is important for correlation with the European chronology because its base is established within the Cenomanian as marine fossils in the underlying unconformable beds of the Washita Group are of Cenomanian Age.

Megafauna

The continuous sequence of the local fauna defined by Stelck et. al. (1958) at the type area is as follows:-

Upper Cenomanian	<u>Inoceramus dunveganensis</u> McLearn	)	
	<u>Inoceramus rutherfordi</u> Warren	)	At the
		)	type
Lower Cenomanian	<u>Brachidontes</u> cf. <u>B. fulpensis</u> Stephenson	)	area
	<u>Pleurobema dowlingi</u> McLearn	)	

The following additional Mollusca from the lower Dunvegan Formation are also described by Warren and Stelck (1958) as their relationship seems to be Lower Cenomanian, viz. Inoceramus leithensis Warren and Stelck.

Brachidontes cf. tenuisculpta
(Whiteaves)
Unio (Pleurobema) cruiserensis
Warren and Stelck
Panope? sp.
Psammosolen dunveganensis Warren

TABLE 2a.

DUNVEGAN SPECIES THAT OCCUR IN FORMATIONS IN THE UNITED STATES OF AMERICA

WOODBINE FORMATION (TEXAS)	TUSCALOOSA FORMATION (ALABAMA)	MAGOTHY FORMATION (N.J., DEL., MD., D.C., MASS., N.Y.)
<u>Ficus daphnogenoides</u> (Heer) Berry	<u>Sphenopteris stricta</u> (Newberry)	<u>Geinitzia formosa</u> Heer
<u>Magnolia boulayana</u> Lesquereux	<u>Geinitzia formosa</u> Heer	<u>Widdringtonites reichii</u> (Ettingshausen) Heer
<u>Magnolia lacoearia</u> Lesquereux	<u>Widdringtonites reichii</u> (Ettingshausen) Heer	<u>Ficus daphnogenoides</u> (Heer)
<u>Cinnamomum heeri</u> Lesquereux	<u>Ficus daphnogenoides</u> (Heer) Berry	<u>Magnolia boulayana</u> Lesquereux
<u>Platanus latiloba</u> Newberry	<u>Magnolis boulayana</u> Lesquereux	<u>Magnolia lacoearia</u> Lesquereux
	<u>Magnolia hollicki</u> Berry	<u>Magnolia hollicki</u> Berry
	<u>Laurophyllum flexuosum</u> (Newberry) Bell	<u>Laurophyllum flexuosum</u> (Newberry) Bell
	<u>Cinnamomum heeri</u> Lesquereux	<u>Cinnamomum heeri</u> Lesquereux
	<u>Platanus latiloba</u> Newberry	<u>Credneria macrophylla</u> Heer
	<u>Platanus affinis</u> Lesquereux	<u>Diospyros Lesquereux</u> Knowlton and Cockerell
	<u>Hymenaea fayettensis</u> Berry	
	<u>Diospyros Lesquereuxi</u> Knowlton and Cockerell	

TABLE 2b.

DUNVEGAN SPECIES THAT OCCUR IN FORMATIONS IN THE UNITED STATES OF AMERICA

RARITAN FORMATION
(N.J., N.Y.)Sphenopteris stricta (Newberry)Geinitzia formosa HeerWiddringtonites reichii (Ettingshausen) HeerFicus daphnogenoides (Heer) BerryMagnolia boulayana LesquereuxMagnolia lacoeana LesquereuxMagnolia hollicki BerryLaurophyllum flexuosum (Newberry) BellCinnamomum heeri LesquereuxPlatanus newberryana HeerDalbergia hyperborea HeerAraliaephyllum rotundiloba (Newberry) FritelDAKOTA FORMATION
(KANS., IOWA, NEBR., COLO.)Ficus daphnogenoides (Heer) BerryFicus glascoeana LesquereuxMagnolia boulayana LesquereuxMagnolia lacoeana LesquereuxLiriodendron giganteum Lesquereux parsLaurophyllum flexuosum (Newberry) BellCinnamomum heeri LesquereuxPlatanus newberryana HeerPlatanus latiloba NewberryPlatanus affinis LesquereuxAmpelophyllites attenuatus (Lesquereux) KnowltonAraliaephyllum rotundiloba (Newberry) FritelDiospyros lesquereuxi Knowlton and Cockerell

There are a number of additional fossils reported from the Dunvegan Formation by Stelck (1962), Stott (1963), Irish (1965). However, such fossils are not diagnostic within the formation.

The two guide fossils in the formation are Inoceramus dunveganensis McLearn and Inoceramus rutherfordi Warren. The top of the Dunvegan Formation as defined by Crickmay (1944) comes at about the stratigraphic position of Inoceramus dunveganensis McLearn, while the palaeontological studies of Stelck et. al. (1958) assigned these guide fossils to Upper Cenomanian. Later Irish (1965), while mapping the Rocky Mountain Foothills of Alberta between latitudes 53° 15' and 54° 15', noted the presence of these two guide fossils only in, what he called the lowerpart of "Dunvegan" of that region.

Brachidontes cf. B. fulpensis Stephenson, and Pleurobema dowlingi McLearn, were arbitrarily assigned to the lower Cenomanian.

Microfauna

A limited microfauna reported by Stelck et. al. (1958) from the middle portion of the Dunvegan Formation at the type locality includes:-

Saccamina sp.

Tritaxia sp.

Trochammina rutherfordi variety 2 Stelck and Wall

Microfloral Consideration

Surface samples collected at the Dunvegan type section were analysed for their microfloral content. The described microflora includes 18 species of microplankton, 94 species of spores and pollen and 8 species of megaspores. A gradual increase in the number of angiosperm pollen grains is indicated, from lower to upper part of the formation.

The presence of advanced angiosperm pollen grains is indicative of an age, later than Albian, while the absence of typical Turonian microflora would suggest a pre-Turonian age of the sediments. An early Late Cretaceous age is reasonable for the sediments. This conclusion supports the age assignments made by Stelck et. al. (1955) and Bell (1963).

CHAPTER THREE - PALEOECOLOGICAL INTERPRETATIONS AND COMPARISON OF
MEGAFLORA AND MICROFLORA

The paleoecology of the Dunvegan Formation based on microflora has limitations imposed by the deltaic nature of sediments. The wind direction and constant turbulence may greatly influence the distribution of microflora in a delta. Thus a broad general idea of the paleoecology of the Dunvegan microflora can be outlined.

The microflora described is provisionally assigned to modern taxa and is divided into six assemblages:

1. The marine microplankton.
2. The angiosperm assemblage, including monocotyledons and dicotyledons.
3. The cycad assemblage related to cycadales.
4. The conifer assemblage represented by families, Pinaceae, Podocarpaceae, Araucariaceae and Taxodiaceae.
5. The Ephedra assemblage represented by two species.
6. The fern assemblage, dominated by families Lycopodiaceae and Schizaeaceae.

Microplankton

10 genera and 18 species of microplankton indicate a brackish to marine environment. Throughout the type section, the microplankton are uniformly distributed. One sample collected at Hines Creek had no microplankton, indicating fresh water origin.

Angiosperm Pollen

Monocotyledonae

Family: Liliaceae, 1 genus and 2 species. Cosmopolitan distribution, localized in swampy communities.

Dicotyledonae

Family: Betulaceae, 1 genus and 1 species.

A characteristic family of temperate regions of north and south hemispheres.

Family: Nymphaeaceae, 1 genus and 1 species. Cosmopolitan. Water or marsh plants with generally submerged or floating leaves.

Angiospermae - Incertae Sedis, 6 genera and 13 species have uncertain affinities. However according to some workers the genus Tricolpites belongs to the cosmopolitan family Salicaceae. Similarly Tricolporates may belong to family Rhizophoraceae, which occurs on tropical shores.

The presence of families Liliaceae and Nymphaeaceae remain of particular interest, because their presence reflects the presence of swampy, fresh water ponds or marshy areas in the Dunvegan delta.

Pteridosperm and Gymnosperm Pollen

Class: Pteridospermae.

Family: Caytoniaceae. A single species recovered is considered an extinct group.

Class: Gymnospermae.

Order: Cycadales. 1 genus and 4 species. The family Cycadaceae is restricted to tropics and subtropics at present. Cycas at present occurs from Australia to Southern Japan and Madagascar.

Order: Coniferales: 9 genera and 13 species. One species belongs to the family Taxodiaceae, one species to the family Araucariaceae, 6 species to the family Pinaceae, 4 species to Podocarpaceae. The general distribution of conifers at present ranges from subarctic to subtropical Zones, and they are generally confined to the elevated areas. Araucaria

is found in New Zealand, Australia and South America. The Podocarps are largely restricted to the Southern hemisphere. The presence of conifers indicate cool or a moist upland habitat.

Order: Gnetales.

Family: Ephedraceae: 1 genus and two species. Mainly tropical and subtropical. Ephedra at present occurs in arid regions of tropical and subtropical areas of northern and southern hemispheres.

Microspores

Division: Bryophyta.

Family: Sphagnaceae: 1 genus and 1 species. Cosmopolitan, found in bogs and ponds where the water is acidic. This indicates a wet lowland area.

Division: Pterophyta.

Family: Lycopodiaceae: 7 genera and 10 species. Cosmopolitan, found chiefly in tropical and subtropical forests but extend into temperate and arctic zones.

Family: Schizaeaceae: 4 genera and 14 species. Mostly occur in tropical and subtropical forests. However some species of Schizaea occur from New Jersey, northward to Ontario e.g. S. pusilla.

According to Singh (1964), the family Schizaeaceae reached its climax during the Early Cretaceous times in western Canada. Although during early Upper Cretaceous times this family shows a decline in its abundance, yet it continues to be well represented. Out of 53 species of ferns spores in the Dunvegan Formation, 14 species belong to the family Schizaeaceae.

Family: Gleicheniaceae: 1 genus and 1 species. Mainly occurs in tropical areas but also extends into warm temperate regions.

Family: Cyatheaceae: 1 genus and 2 species. Mainly occur in tropic and subtropic areas but may extend into temperate areas, especially in the southern hemisphere; a chief flora of humid forests.

Order Filicales - Incertae Sedis: 16 genera and 26 species of microspores are of uncertain affinities.

Megaspores: 6 genera and 8 species. These spores are separated from microspores only on size basis. The genus Arcellites, among the megaspores recovered from the Dunvegan Formation remains of interest, because of its aquatic type of morphology. Cookson and Dettmann (1958) consider these spores closely related to aquatic family Marsiliaceae. This indicates the presence of ponds and shallow lakes around the source area during Dunvegan times.

Summary

In summary the Dunvegan microflora is primarily an angiosperm, conifer, and fern-cycad assemblage. This indicates that the Peace River area during the Dunvegan times may have had a varied topography. The presence of gymnosperm pollen indicates presence of an elevated and well developed land area. Ferns may have predominated in swampy basins which likely were present in large numbers along the Dunvegan delta or on a major drainage flood plain. Most of the angiosperm flora has uncertain affinities with modern taxa. Their abundance in the type section however may indicate a near delta vegetation. The palynological assemblage indicates a cool temperate to humid subtropical climate during Dunvegan times. The ephedralean pollen indicating desert or mountainous area, may have been derived outside the source area.

The presence and absence of microplankton within the type section indicates fluctuating marine and non-marine deposition of the formation.

Comparison of Megaflora and Microflora:

Bell (1963) reported a small number of filicales and gymnospermous plants from the Dunvegan Formation. In contrast the microflora shows a larger number of filicales spores and gymnosperm pollen.

This discrepancy may be due to:-

1. The filicales and gymnosperm megaflora may not be preserved in full.
2. The larger number of spores may be due to the presence of Lower Cretaceous reworked sediments, of which the Dunvegan delta is formed in part.

The angiosperm megaflora reported by Bell (1963) makes up less than sixty percent when compared to the angiosperm microflora. This percentage is based upon the ratio of angiosperm megaflora and microflora without any direct comparison. No comments could be made unless a more extensive study were undertaken.

CHAPTER FOUR - AGE AND CORRELATION OF THE DUNVEGAN MICROFLORA

The faunal and floral studies of the Dunvegan Formation by Stelck et. al. (1955, 1958) and Bell (1963) indicate an early Upper Cretaceous (Late Cenomanian) age for the Dunvegan Formation.

Undoubtedly the microflora, of greatest importance in assigning a refined age to the Dunvegan Formation, comes from the first appearance of higher evolved angiosperm pollen grains during Cenomanian times in Western Canada. The extensive studies of Pocock (1962) and Singh (1964) indicate an absence of angiosperm pollen up to Middle Albian times. However, Norris (1967) recovered a number of angiosperm pollens from the Lower Colorado Group (Albian ---? Cenomanian) of Central Alberta and Brenner (1963) reported 8 species of angiosperm pollen (tricolpites) from Albian sediments of the Maryland coastal plain (U.S.A.). Similarly Bolkhovitina (1953) and Couper (1960) reported undoubted angiosperm pollen grains from the Lower Cretaceous (Albian) sediments of Russia and Europe.

The Dunvegan microflora can be differentiated from any such reported occurrence of Albian angiosperm microflora, by the presence of triporate pollens, none of which has been reported from Lower Cretaceous sediments. Therefore, the presence of many tricolpate, tricolporate species and the appearance of triporate pollen grains in the Dunvegan Formation indicate an age later than Albian (Upper Cretaceous?). The absence in the Dunvegan of advanced types of angiosperm pollen such as reported by Krutzsch (1957) from the Turonian sediments of Germany (except for the genus Latipollis) indicates an early Late Cretaceous age (i.e. pre-Turonian) for the Dunvegan Formation. This agrees with ammonite evidence.

TABLE 3.
MICROFLORAL COMPARISON

NORTH AMERICA					EUROPE	
Angiosperm Pollen	Dunvegan Formation W. Canada	Woodbine Formation Okla (U.S.A.)	Minnesota (Cenomanian) (U.S.A.)	Tuscaloosa Formation Alabama (U.S.A.)	Raritan Formation New Jersey (U.S.A.)	Portugal (Cenomanian)
Triporate	Present	Absent	Absent	Present	Present	Present
Polycolpate	Rare	Rare	Absent	Absent	Absent	?Present
Tricolporate	Present	Present	Present	Present	Present	Present
Tricolpate	Present	Present	Present	Present	Present	Present
Monocolpate	Present	Present	Present	-	-	Present

Intracontinental Palynological Comparison

1. Comparison with Cenomanian microflora of Minnesota.

Pierce (1961) recovered a large number of spores and pollen types similar to Dunvegan microflora from the 'Dakota' of Minnesota. Comparison at the generic or species level indicates that a number of his spores have been reported from the Lower Cretaceous of Central Alberta (Singh and Norris, 1967). Such spores happen to be long ranging and, therefore, of little stratigraphic importance, in terms of refined dating.

The stratigraphically important angiosperm pollen common to both the formations are:-

1. Liliacidites variegatus
2. Tricolpites spp.
3. Tricolporopollenites spp.

Triporate genera like Latipollis and Triporopollenites recovered from the Dunvegan are absent from the Cenomanian of Minnesota. This may indicate that the Dunvegan Formation is slightly younger than Cenomanian of Minnesota if the environmental conditions were not responsible for such an absence. In addition the presence of gymnosperm pollen in both formations indicates the presence of an elevated source area.

The presence of triporate pollen indicates a higher stratigraphic position for Dunvegan sediments when compared to Cenomanian microflora of Minnesota.

2. Comparison with Cenomanian microflora of Atlantic Coastal region.

Groot and Penny (1960) and Groot et. al. (1961) described spore and pollen of the Cenomanian sediments of the Atlantic region of

the United States. The age of Cretaceous sediments in this region is traditionally in dispute.

Comparison of the Dunvegan angiosperm microflora at the generic level shows a close similarity to Lower Raritan Formation in New Jersey and lower part of Tuscaloosa Formation in Alabama. These formations like the Dunvegan show a lack of typical Turonian and Senonian microflora, excepting Latipollis pollen, which is common to all of them.

Although the Dunvegan Formation has additional triporates, yet the genus, Plicapollis is absent, on which basis Groot et. al. (1961) presumably assigned the upper part of the Raritan Formation in New Jersey to the Turonian stage.

The direct comparison of megaflorea and microflora of the Dunvegan is not attempted here, but from the report of Bell (1963) of nine angiosperm plants of Dunvegan that occur in the Tuscaloosa five also occur in the Raritan. Future work may be needed to compare angiosperm megaflorea represented by microflora in the Dunvegan. However, from the work of Bell (1963) and the present study, a close similarity between the Dunvegan, the lower part of the Raritan in New Jersey and the lower Tuscaloosa of Alabama is indicated.

This indicates that the presence of tricolpate, tricolporate and triporate pollen grains and the absence of typical Turonian and Senonian microflora like Sporopollis, Trudopollis and Plicapollis in the Dunvegan compares well with the lower Raritan of New Jersey and the lower Tuscaloosa of Alabama of the eastern United States.

3. Comparison with pre-Selma microflora.

The preliminary microfloral studies carried out in pre-Selma

sediments in western Alabama by Leopold and Pakiser (1964) indicates that these rocks carry a part of the angiosperm flora similar to one reported by Krutzsch (1957, 1959) from five Turonian localities in Germany.

It is interesting to note that Krutzsch (1959) described some of the structurally advanced types of pollen in Germany, such as Complexipollis, Monstruosipollis, Taneria, Turnopollis and Latipollis. Such pollen are undoubtedly well dated as Turonian by the presence of Inoceranus labiatus (Schlotheim). These types of pollen are first time reported in North America (Leopold and Pakiser (1964) in the Eoline Member of the Coker Formation (in the Tuscaloosa Group of western Alabama). Such type of pollen are not present in the Dunvegan type area, excepting the genus Latipollis.

The Dunvegan Formation shows an absence of structurally advanced angiosperm pollen found in pre-Selma beds and assigned by Leopold and Pakiser (1964) to early Late Cretaceous.

4. Comparison with the Red Branch Member (Woodbine Formation) microflora in Oklahoma.

The microflora of the Red Branch Member of the Woodbine Formation (Hedlund 1966) gives an important comparison because of its long established Cenomanian Age. A number of Dunvegan spores, tricolpate and tricolporate pollen are common to both the formations. However, triporate pollen recovered from the Dunvegan are not found in the Red Branch Member. If environmental conditions in the Red Branch were not responsible for the absence of triporate pollen, then the Dunvegan Formation may be somewhat younger than the Red Branch Member.

The suggestion that the Dunvegan may be at a higher stratigraphic position than the Red Branch Member does not invalidate the correlation proposed by Stelck and Wall (1955) with the Woodbine Formation of Oklahoma (Hedlund 1966). The unconformity between the Washita Group and the Woodbine Formation is regional, representing the Gulfian - Comanchean break. Secondly the Red Branch Member is a discontinuous lenticular patch of sediments which is not recognized beyond the Red River area of Oklahoma (Hedlund, 1966) unlike the brackish Euless Member with which Stelck et. al. (1955) correlated the top of Dunvegan.

This indicates that the type 'Dunvegan' may be younger than Red Branch Member (fig. 6).

Intercontinental Palynological Comparison

Comparison with the Cenomanian of Portugal.

Groot and Groot (1962) described the microflora of Aptian, Albian and Cenomanian deposits of Portugal. They recorded the first abundance of angiosperm pollen during Late Cenomanian times.

A comparison of the microflora of the Dunvegan with that of the Cenomanian sediments of Portugal, on the basis of angiosperm pollen indicates a close relationship between the two. The Dunvegan, the Atlantic Coastal plain sections and the rocks of Portugal have pollen grains with various morphological features in common. The interesting genus Latipollis which probably makes its first appearance in Cenomanian times is present in all the three areas.

This indicates that the close resemblance of microflora already observed by Groot and Groot (1962) on either side of the Atlantic Ocean also extends inland to the Dunvegan microflora.

CORRELATION WITH WOODBINE OF TEXAS

CORRELATION WITH WOODBINE OF OKLAHOMA

	Texas	Peace River Alberta		Oklahoma	Peace River Alberta
Woodbine Formation	Templeton Member	Lower Kaskapau Formation		Templeton Member	
	Lewisville Member			Lewisville Member	
	Pepper shale				
	Eulless Member marine	Dunvegan Formation		Red Branch Member non-marine	Dunvegan Formation
	Dexter Member			Dexter Member	

Modified from Stelck and Wall
(1955, p. 26).

This paper. Oklahoma section
after Hedlund (1966)

Figure 6.

Correlations with the Woodbine Formation of Texas and Oklahoma.

CHAPTER FIVE - PALYNOLOGY
NOMENCLATURE AND CLASSIFICATION

The nomenclature of the spores (the term spores is used in collective sense and denotes spores and pollen) in the present study is based upon the rules of priority and typification as laid down in the International Code of Botanical Nomenclature (1961).

The morphologic system of classification used at the generic and specific level in the present work is based on the works of Potonie (1956, 1958 and 1960). The binomial designation used for all species and the genera to which the species belongs are regarded as form taxa (artificial). Although they are based on morphological features only, these form genera have been assigned to their respective natural families. Botanical affinities of many spores have been attempted in order to arrive at some sort of a natural classification.

Descriptive terms

One of the serious draw backs in Palynology is the unrestricted sense of the terms in descriptive terminology. This is vividly demonstrated in the work of Kremp (1965). Although this is a by product of a rapidly growing science yet this aspect of palynology ought to have been seriously considered. A species based upon minor morphological features is naturally handled by a group of definite descriptive terms, which unfortunately may not convey a strict sense to either the writer or to the reader. This chaos arises from the individual's choice in selecting the descriptive terminology of a particular author. At present workers either list the glossary of descriptive words in their publications or even venture revision of the previously defined terms. These attempts warrant an

early decision on the formulation of terms conveying a restricted meaning. The proliferation of terminology is to be avoided and with this objective in mind at least a consistent spore terminology for the Cretaceous sediments of Alberta may be maintained. Therefore the terms used in the present study are essentially after the works of Jansonius (1962) Pocock (1963), Singh (1964), Vagvolgyi (1964) and Srivastava (1965 and 1966).

DESCRIPTIVE PALYNOLOGY

MARINE MICROPLANKTON

order Dinoflagellata

Family Peridinidae

Genus PALAEOPERIDINIUM Deflandre, 1934

- 1934 Palaeoperidinium Deflandre, Compt Rend Acad. Sci. Vol. 119, pp. 967-968.
- 1967 Palaeoperidinium cretaceum Pocock - Palaeontographica Bd. III, Abt. B, p. 80, Fig. 219-221.

DIAGNOSIS: Fossil vesicle peridinid in appearance; plated; but tabulation not distinct enough to permit precise generic assignments. Up till 1965 about 18 species were identified under this genus without a designated type species. Therefore Palaeoperidinium cretaceum Pocock, is proposed as the type species.

PALAEOPERIDINIUM CRETACEUM Pocock, 1962

Plate 1, Figs. 1 and 7

- 1962 Palaeoperidinium cretaceum Pocock, 1962, Palaeontographica, Band III, Abt. B, p. 80, Pl. 14, Figs. 219-221.
- 1964 Palaeoperidinium cretaceum Pocock - Singh, Res. Coun. Alberta, Bull. 15, p. 134, pl. 18, fig. 1.

DESCRIPTION: Vesicle longer than broad; epitheca tapering to a point on which a conical apical horn is present; hypotheca broadly convex and carrying two unequal antapical horns; a spiral equatorial girdle developed; thecal wall thin with little indication of plates or longitudinal furrows; surface faintly granulose.

SIZE: Length - 90 microns.

Breadth - 75 microns.

Length of the longer antapical horn - 13 microns.

Length of the apical horn - 18 microns.

DISTRIBUTION: Cretaceous. This species is found common in the Upper part of the type section.

FIGURED SPECIMEN: Pl. 1, figs. 1, 6, slide no. DUN 213-3
Co-ord. 30.6/121.6; DUN 213-2 Co-ord. 44.2/109.6.

PALAEOPERIDINIUM NUDUM Downie, 1957

Plate I, Figs. 2 and 3

1957 Palaeoperidinium nudum Downie, Geol. Soc. Lon. Quart. J. 112,
p. 424, pl. 20, fig. 11.

DESCRIPTION: Vesicle oval; tapering to a point on which a solid apical horn present; opposite end broadly convex; equatorial girdle not distinct; thecal wall thin and colourless with faint indication of plates; few longitudinal furrows running across the vesicle are faintly visible; few short spines on the wall.

SIZE: Av. length - 88 microns.

Av. breadth - 75 microns.

Av. length of apical horns - 8-10 microns.

DISTRIBUTION: Cretaceous. Present in the upper part of the type section.

FIGURED SPECIMEN: Pl. 1, figs. 2, 3, slide no. DUN 126-3, Co-ord. 66/117.3, 47/123.

PALAEOPERIDINIUM sp. A

Plate 1, Fig. 4

DESCRIPTION: Vesicle broader than long, oblong; two well developed horns, one long and sharply tapering; other horn broadly triangular and short; thecal wall with furrows; surface finely granulose, plates indistinct.

REMARKS: The long horn is probably the apical horn and shorter is antapical horn.

SIZE: Length = 52 microns.

Breadth = 59 microns.

Apical horn = 33 microns.

Antapical horn = 15 microns.

DISTRIBUTION: Few specimens were recovered in the middle and upper parts of the type section.

FIGURED SPECIMEN: Pl. 1, fig. 4, slide no. DUN 213-2

Co-ord. 27.9/124.2.

PALAEOPERIDINIUM sp. B

Plate 1, Fig. 5

DESCRIPTION: Vesicle rounded; with fairly developed apical horn a distinct equatorial girdle developed which seems to be slightly bifurcating; tabulation indistinct, body covered with spines.

SIZE: Length = 65 microns.

Breadth = 65 microns.

DISTRIBUTION: A single specimen was recovered in the upper part of type area.

FIGURED SPECIMEN: Pl. 1, fig. 5, slide no. 213-3, Co-ord.

54.7/114.2.

Order Hystriosphaeeridea

Family Hystriosphaeeridae

Genus HYSTRICHOSPHAERIDIUM Deflandre, 1937, emend. Eisenack, 1958

- 1838 Xanthidium tubiferum Ehrenberg, Abhandl. Kon. Akad. Wiss. (Berlin), pt. 1, fig. 19.
- 1933 Hystriosphaea tubifera Wetzel, Palaeontographica, Band 77, Abt. A, p. 40, Band 78, Abt. A, fig. 16.
- 1937 Hystriosphaeeridium tubiferum (Ehrenberg) Deflandre, Ann. Paleont., vol. 26, p. 69, pl. 13, figs. 2, 4, 5. (type species).
- 1958 Hystriosphaeeridium Deflandre, emend. Eisenack, Neues Jahrb. Geol. Palaeont., Abhandl., vol. 106, p. 399-400.
- 1964 Hystriosphaeeridium tubiferum (Ehrenberg) Deflandre - Singh. Res. Council Alberta Bull. 15, p. 137, pl. 18, fig. 5.

DIAGNOSIS: Hystriosphaeeridae with non-plated central vesicle, bearing numerous, commonly funnel-shaped processes, generally widening from base to apex and opening towards the outer end.

Genus Hystriosphaeeridium was restricted by Eisenack (1958) to those forms in which the processes are open at the outer end. Hystriosphaeeridium can be distinguished from the Genus Hystriosphaea by the presence of spiral girdle and polygonal areas on the central body.

HYSTRICHOSPHAERIDIUM TUBIFERUM (Ehrenberg) Deflandre, 1937

Plate 1, Figs. 7, 8.

(Synonymy as for genus)

DESCRIPTION: Vesicle thin, smooth, circular to oblong in outline; processes long, narrow at the base and broadening on towards the apex, hollow opening at the apex; lips irregular and frayed.

SIZE: Av. vesicle diameter - 70 microns.

Av. length of processes - 40 microns.

Av. width of processes at the base - 7-13 microns.

Av. width of processes at the apex - 12-20 microns.

Number of processes - 7 or more.

DISTRIBUTION: Pocock (1962), Singh (1964) reported this species from L. Cretaceous Mannville Group; Deflandre (1937) reported it from Aptian; Eisenack (1958) reported it from Upper Cretaceous of Europe. This species is common at the type area.

REMARKS: This species is of little stratigraphic value because of its long stratigraphic range.

FIGURED SPECIMEN: Pl. 1, Figs. 7, 8, slide no. DUN 213-3, Co-ord. 58.3/116.8.

HYSTRICHOSPHAERIDIUM ALBERTENSE Pocock, 1962

Plate 2, Figs. 1, 2.

- 1962 Hystrichosphaeridium albertense Pocock, Palaeontographica, Band III, Abt. B, p. 82, pl. 15, figs. 226, 227.
- 1964 Hystrichosphaeridium albertense Pocock - Singh, Res. Coun. Alberta, Bull. 15, p. 138, pl. 18, fig. 6.

DESCRIPTION: Vesicle smooth, circular in equatorial section, processes long, cylindrical in cross section, hollow and more or less equal in width except towards the apices, where they broaden out slightly into a funnel shaped structure; lips of process irregular with few spines.

SIZE: Vesicle diameter - 60 microns.

Length of processes - 20 microns.

Width of processes - 7-12 microns.

Number of processes - app. 12.

DISTRIBUTION: Cretaceous, (Albian, Cenomanian). Few specimens were recorded in the Middle of the type section.

FIGURED SPECIMEN: Pl. 1, figs. 1, 2, slide no. DUN 126-3, Co-ord. 37.4/117.5.

HYSTRICHOSPHAERIDIUM cf. H. SALPINGOPHORUM Deflandre, 1937

Plate 2, Figs. 3, 8.

- 1854 Xanthidium tubiferum Ehrenberg, Mikrogeologie XXIX No. 48.
- 1935 Hystrichosphaera salpingophora Deflandre, Bull. Biologie, LXXIX, p. 232, pl. IX, fig. 1.
- 1937 Hystrichosphaeridium salpingophorum Deflandre, Ann. de Paleontologie, T.26, 1937, Micro. des silex cretaces, p. 15.

DESCRIPTION: Vesicle smooth, elliptical; processes hollow, cylindrical, more or less equal width, with a slight broadening at the apices; lips irregular without spines.

SIZE: Vesicle diameter - 52 microns.

Length of processes - 26-30 microns.

Width of processes - 8-10 microns.

Width at the apex - 10 microns.

Number of processes - 7 or more.

DISTRIBUTION: Deflandre (1937) reported Hystrichosphaeridium salpingophorum from Upper Cretaceous Cenomanian in France. A single specimen was recovered at 213 feet from the bottom of the type section.

REMARKS: This species differs from Hystrichosphaeridium albertensis Pocock, by its fairly uniform width of processes from base to apex, lack of distinct and well developed trumpet shaped process and absence of spines and less complex lips. From Hystrichosphaeridium salpingophorum Deflandre, this species differs in size and possibly the number of processes.

FIGURED SPECIMEN: Pl. 2, figs. 3, 8, slide no. DUN 213-3, Co-ord. 51/121.2.

HYSTRICHOSPHAERIDIUM sp.

Plate 2, Figs. 4, 7.

DESCRIPTION: Vesicle oval, smooth; processes slender and hollow, uniform width from base to apex, open, lips modified into short spines, numerous.

SIZE: Vesicle diameter - 65 microns approx.

Av. length of processes - 25 microns.

Av. width of processes - 5-7 microns.

DISTRIBUTION: Rare at the type area.

FIGURED SPECIMEN: Pl. 2, figs. 4, 7, slide no. DUN 213-2,
Co-ord. 43.7/108.

Genus WILSONASTRUM Jansonius, 1962

1962 Wilsonastrum colonieium Jansonius, Palaeontographica Bd. 110, Abt. B,
p. 88-89, plate 16, fig. 45 (type species).

DIAGNOSIS: Fossil planktonic micro-organism of probably algal affinity; vesicle triangular, tetrahedral or polygonal; the corners drawn out in short or long projections, hollow, closed at the tips; one or two short bristles may be present or slightly differentiated area near the centre of the side of the vesicle, which serves as basis for the flagellum or bristles, vesicle wall laevigate or with minor ornamentation.

DISCUSSION: This genus differs from genus Veryhachium Deunff (Genus type V. trisulcum Deunff 1959) and Hystriosphæridium trispinosum Eisenack in being smaller, with less pronounced and shorter spines and a thin wall. The presence of a flagellum or bristle is not reported in Veryhachium.

WILSONASTRUM sp.

Plate 2, Figs. 5, 6.

DESCRIPTION: Vesicle roughly spherical; wall smooth, moderately thick, vesicle drawn into gently tapering spines, hollow, closed at the tip, recurved, three in number; specimen photographed has one arm resting

on the vesicle, a small bristle is present, a distinct fold visible on vesicle.

SIZE: Vesicle diameter - 31 microns.

Length of spines - 15 microns.

Width of spine at base - 4 microns.

Length of bristle - 4 microns.

Width of bristle - less than 1 micron.

REMARKS: This species differs from Wilsonastrum colonicum. Jansonius by its more or less spherical shape, recurved spines and moderately thick wall.

DISTRIBUTION: Few specimens recorded at 126 feet from the bottom of type section.

FIGURED SPECIMEN: Pl. 2, figs. 5, 6, slide no. DUN 126-3, Co-ord. 48/116.5.

Genus MICRHYSTRIDIUM Deflandre, emend. Staplin,
emend. Downie and Sargeant, 1963

Genus MICRHYSTRIDIUM Deflandre, (1937)

- 1935 Micrhystridium inconspicuum Deflandre, Considerations Biologiques Sur les organismes d' origine Palaentologique Conservees dans les Silex de la craie, Bull. biol. Fr. Belg. p. 233, pl. 9, figs. 11-12 (type species) Cretaceous, France, 9 microns.
- 1961 Micrhystridium Deflandre, Paleont. 4, p. 408.
- 1963 Micrhystridium Deflandre, Paleont. 6, p. 92.

DIAGNOSIS: Hystrichospheres with spherical to oval shells not divided into plates; processes with closed tips, simple, rarely branching without distal connection of any kind, processes of one type;

diameter not more than 20 microns.

MICRHYSTRIDIUM cf. M. INCONSPICUUM Deflandre, 1935

Plate 2, Fig. 9.

(Synonymy as for genus)

DESCRIPTION: Vesicle roughly circular, wall relatively thick, with secondary folding, spines short, moderately tapering to a point, hollow, distribution uniform over body.

SIZE: Vesicle diameter - 20 microns.

Av. length of processes - 5-6 microns.

Av. width of base of processes - 1-2 microns.

Number of spines - 20 or more.

DISTRIBUTION: Few specimens recovered from the upper part of the type section.

FIGURED SPECIMEN: Pl. 2, fig. 9, slide no. DUN 213-2, Co-ord. 61.5/107.6.

Genus BALTISPHAERIDIUM (Eisenack) Downie and Sargeant, 1963

1958 Baltisphaeridium longispinosum. Eisenack, Neues Jahrb. Geol. Paleont. Abhandl., vol. 106, p. 398 (type species).

1963 Baltisphaeridium Downie and Sargeant, on the Interpretation and status of some Hystriosphere Genera, Paleont. 6, p. 89.

DIAGNOSIS: Hystriospheres with spherical to oval shell; no plates; processes simple or branching, hollow to solid, always closed tips, processes of single type, but two or more types may be present; size of shell more than 20 microns.

REMARKS: In general terms the fundamental difference between genera Baltisphaeridium and Micrhystridium is in size. However this size limit may be disputed. It doesn't seem convincing to establish two genera on size parameters above. However Downie and Sargeant (1963) conclude "We consider that the genera Micrhystridium and Baltisphaeridium express two natural size modes, and the size boundary separating them should be retained at least until more compelling evidence for emendation of the genera is available". In the present study genera Baltisphaeridium and Micrhystridium have been distinguished according to the emendations made by Downie and Sargeant (1963).

BALTISPHAERIDIUM sp.

(Plate 2, Fig. 10, Plate 3, Fig. 2)

DESCRIPTION: Vesicle ellipsoidal, smooth, thin; spines tapering but hollow and closed at the apex, almost equal to the radius of the vesicle, distributed all over the vesicle.

SIZE: Length of the vesicle - 52 microns.

Width of vesicle - 36 microns.

Av. length of spines - 15 microns.

Av. width at base of spine - 2-3 microns.

Number of spines - 20 or more.

DISTRIBUTION: In Middle and Upper part of the type section.

FIGURED SPECIMEN: Pl. 2, fig. 10, slide no. DUN 213-3,

Co-ord. 47.3/125.2.

Genus LEIOFUSA Eisenack, 1938

1938 Leiofusa fusiformis Eisenack, Z. Geschiebeforsch 14:1-30.

DIAGNOSIS: Oval to elongate spindle shaped cyst. with smooth wall.

LEIOFUSA sp.

Plate 3, Figs. 1, 3.

DESCRIPTION: Vesicle spindle shaped, moderately thin, plates present on central part of vesicle probably more than ten.

SIZE: Total length - 91.

Width at centre - 26.

REMARKS: The specimen described would actually go into the genus Ceratum Schrank 1793. However, genus Ceratum has been questioned by Eisenack (1961) and Evitt (1961). Eisenack (1961) would accommodate the species of Ceratum in other genera. Therefore genus Ceratum is considered invalid for the present work.

INCERTAE SEDIS

Genus PALAEOSTOMOCYSTIS Deflandre, 1935

1935 Palaeostomocystis reticulata Deflandre, Bull. biol. Fr. Bdg. 69, p. 234, pl. 9, fig. 13, Cretaceous France 18 (type species).

DIAGNOSIS: Shells sometimes closed, sometimes pierced by pore, often minute.

REMARKS: The genus Fromea can be distinguished from

Palaeostomocystis, by the presence of an equatorial girdle in the former genus.

DISCUSSION: The type species of genus Palaeostomocystis (P. reticulata Deflandre, 1935) is 18 microns in size. However later workers seem to have ignored the size range limit of the genus without any emendations. For example Palaeostomocystis apiculata Cookson and Eisenack (1960) has a size range of 38-62 microns X 19-35 microns.

PALAEOSTOMOCYSTIS sp.

Plate 3, Fig. 4

DESCRIPTION: Shell roughly spherical, relatively thick walled, smooth outer shell, membrane thick; aperture wide, sunken.

SIZE: Shell diameter - 98 microns.

Aperture width - 18 microns.

DISTRIBUTION: Two specimens were recovered from upper part of the type section.

FIGURED SPECIMEN: Pl. 3, fig. 4, slide no. DUN 248-4, Co-ord. 49.6/117.9.

Genus PTEROSPERMOPSIS Wetzel, 1952

1952 Pterospermopsis danica Wetzel, Geol. Jahrb. 66, 391-421, Pl. A, fig. 16, Text fig. 34 (type species).

DIAGNOSIS: Spherical capsule of organic material with an equatorially placed membraneous fringe.

PTEROSPERMOPSIS sp. A

Plate 3, Fig. 5.

DESCRIPTION: Vesicle spherical, smooth, light yellow, fairly thick, equatorial membrane with hollow processes radiating out from the vesicle.

SIZE: Vesicle diameter - 15 microns.

Membrane diameter - 7 microns.

Length of process - 7 microns.

Number of processes - 18 microns.

DISTRIBUTION: Two specimens were recorded in the upper part of the type section.

FIGURED SPECIMEN: Pl. 3, fig. 5, slide no. DUN 191-1, Co-ord. 43.2/113.

PTEROSPERMOPSIS sp. B

Plate 3, Figs. 7, 8.

DESCRIPTION: Central body more or less spherical body wall thick, brown, probably with reticulation (?); membrane-like flanges connect central body with membrane; membrane thin with short processes slightly tapering.

SIZE: Diameter of cyst - 20 microns.

Diameter of whole body - 180 microns.

Width of flange - 3 microns.

DISTRIBUTION: A single specimen recorded from the middle part of the type area.

FIGURED SPECIMEN: slide no. DUN 126.4, Co-ord. 65.5/122.5.

CYST TYPE A

Plate 3, Fig. 6.

DESCRIPTION: Central body thick brown, roughly oval, thin membrane surrounding the central body, flange faintly seen in some membrane thin with radial pattern.

SIZE: Cyst diameter - 10 microns.

Body diameter - 50-60 X 45-52 microns.

DISTRIBUTION: Common throughout the type section.

FIGURED SPECIMEN: Pl. 3, fig. 5, slide no. DUN 126-6,
Co-ord. 41.5/114.4.

CYST TYPE B

Plate 14, Figs. 4,5.

DESCRIPTION: Vesicle ellipsoidal, collapsed; a small tube connected with body, wall unornamented, thin, without any furrows.

SIZE: Total length - 90 microns.

REMARKS: This cyst type conforms with the generic diagnosis of the genus Leiosphaeridia (Eisenack) Downie and Sargeant. However, the presence of a tube around the pylome may need either the emendation of the genus or the creation of a new genus for such types of cysts.

DISTRIBUTION: Two specimens recovered from the upper part of the type section.

FIGURED SPECIMEN: Pl. 14, figs. 4, 5, slide no. DUN 248-3,
Co-ord. 69.2/124.5.

Genus PALAMBAGES Wetzel, 1933

DIAGNOSIS: Cellular colonies, more or less flattened, number of cells variable. In one category the number of cells is between 15 to 20, in the second category cells exceed 100, while in third category cells vary from 20-100. Size of the individual cells ranges between 20 microns to 30 microns, cell wall finely granular.

AFFINITY: Wetzel (1930) considers them as algal colonies. Also states their likeness to egg balls of Planktonic Crustacean. Manum and Cookson (1964) consider them as colonial algae, on the basis of cells in powers of two - a character found in some living colonial algae. According to authors the cells of genus Palambages possess cells in powers of two.

DISTRIBUTION: Wetzel (1961) and Gorka (1963) reported from Upper Cretaceous of Europe. Manum and Cookson (1964) reported from Arctic area in Graham Island and Ellef Ringnes Island.

PALAMBAGES FORM A Manum and Cookson, 1964

Plate, 14, Figs. 6, 7

DESCRIPTION: Cellular colonies; number of cells variable, individual cells variable in size, 13 microns to 26 microns, number of cells between 20 to 40; peripheral cells smaller, in central cells larger in size.

SIZE: Total length of colony - 80 microns or less.

No. of cells in a colony - 20-40 microns.

Size of individual cells - 13-26 microns.

DISTRIBUTION: The 'Dunvegan' specimen looks similar to

the ones described by Manum and Cookson (1964) from Arctic area in Ellef Ringnes Island. Recovered from the upper part of the type section.

FIGURED SPECIMEN: Pl. 14, figs, 6, 7, slide no. DUN 248-6, Co-ord. 64/116.8, 28.8/123.4.

SPORES

FAMILY SPHAGNACEAE

Genus STEREISPORITES Pflug, 1953

- 1953 Stereisporites stereoides (Potonie and Venitz) Pflug (in Thomson and Pflug) Pollen und spores des Mitteleuropaischen Tertiars. Palaeontographica B 89: p. 53 (type species).

DIAGNOSIS: Trilete, laesurae simple, $2/3$ of spore radius, equatorial outline triangular with convex sides, exine smooth and thick.

STEREISPORITES ANTIQUASPORITES (Wilson and Webster) Dettman, 1963

Plate 4, Fig. 1

- 1946 Sphagnum antiquasporites Wilson and Webster, Am. J. Bot. Vol. 33, p. 271-278.
- 1947 Trilites australis Cookson, B.A.N.Z. Antarctic Res. Exp. Rep. Az. p. 136, pl. 15, figs. 58, 59.
- 1953 Sphagnites australis Cookson, Australian J. Botany, vol. 1, p. 463, pl. 1, figs. 1-4.
- 1959 Sphagnum punctaesporites Rouse, Micropal., Vol. 5, p. 308, pl. 1, figs. 25, 26.
- 1962 Sphagnum antiquasporites (Wilson and Webster) Pocock, Palaeontographica, Band III, Abt. B, p. 32, pl. 1, figs. 1-3.

DESCRIPTION: Trilete, laesurae extending $1/2$ to $2/3$ of radius of spore, simple, equatorial outline triangular with strongly convex sides, corners rounded, arcuate thickenings subtend the angles of laesurae, about 1 micron thickened zone around the equator, exine smooth.

SIZE: Equatorial diameter 20 to 33 microns.

DISTRIBUTION: Upper Jurassic, Cretaceous and Tertiary; common in 'Dunvegan' type section.

REMARKS: Stereisporites antiquasporites (Wilson and Webster) Dettmann (1963) can be distinguished from several other species of the genus including the type species by the presence of thickening around the laesurae.

FIGURED SPECIMEN: Pl. 4, fig. 1, slide no. 213-2, Co-ord. 62/110.9.

FAMILY LYCOPODIACEAE

Genus BIRETISPORITES Delcourt and Sprumont emend. Dettmann, 1963

1955 Biretisporites potonieii Delcourt and Sprumont, Mem. Soc. Belg. Geol. 4: 73 p. (type species).

1962 Biretisporites potonieii, Delcourt and Sprumont - Pocock, Palaeontographica, Band 3, Abt. B, p. 36, pl. 1, fig. 17.

DIAGNOSIS: Trilete microspores, trilete aperture enclosed with elevated lips, equatorial outline convexly triangular, exine thick and smooth.

BIRETISPORITES POTONIEI Delcourt and Sprumont, 1955

Plate 4, Figs. 2, 3

DESCRIPTION: Same as for genus.

SIZE: 34 microns.

DISTRIBUTION: L. Mannville beds of Alberta (Pocock, 1962).

Rare.

FIGURED SPECIMEN: Pl. 4, figs. 2, 3, slide no. DUN 191-8,

Co-ord. 43.5/123.5.

Genus DENSOISPORITES Weyland and Krieger emend. Dettmann 1963

1953 Densoisporites velatus Weyland and Krieger, Palaeontographica B 95, p. 12, pl. 4, figs. 12-14 (type species).

1961 Selaginella velata (Weyland and Krieger) Krasnova in Samoilovitch, VNIGRI, p. 35-36, pl. 7, figs. 5, 6.

1963 Densoisporites Weyland and Krieger emend. Dettmann, Proc. Roy. Soc. Vict., Vol. 77, Part 1, p. 83.

DIAGNOSIS: Trilete microspores, spore wall two layered, consisting of an outer sculptured layer loosely enveloping on proximal side attached to a thinner inner layer. Exine equatorially thickened with finely arranged structural elements (but no ornamentation). Inner layer smooth with interr radial thickenings near the proximal pole.

REMARKS: Two species are described under this genus provisionally, because of the lack of few diagnostic characters in these specimens.

DENSOISPORITES sp. A

Plate 4, Fig. 4

DESCRIPTION: Trilete, laesurae simple extending full length

of spore cavity, equatorial outline subcircular, cingulum present, variable, proximal and distal surface of spore cavity and cingulum with rugulate ornamentation, proximal side convex, exine thick.

SIZE: Equatorial length - 60 microns.

DISTRIBUTION: A single specimen was recovered from the lower part of the type section.

FIGURED SPECIMEN: Pl. 4, fig. 4, slide no. DUN 99-1, Co-ord. 65/117.3.

DENSOISPORITES sp. B

Plate 4, Fig. 5

DESCRIPTION: Trilete, laesurae extend to margin of the inner layer, surrounded by a thickened zone, inner layer smooth surrounded by outer faintly striated layer, exine thick, yellow brown.

SIZE: Equatorial diameter 65 microns.

DISTRIBUTION: Recovered from upper part of the type section.

FIGURED SPECIMEN: Pl. 4, fig. 5, slide no. DUN 248-6, Co-ord. 34.6/124.9.

Genus FOVEOTRILETES Van der Hammen ex Potonie, 1956

1949 Triletes scrobiculatus Ross, Bull. Geol. Inst. Uppsala, p. 32, pl. 1, fig. 5.

1956 Foveotrilletes scrobiculatus (Ross) Potonie, Beih. Geol. Jahrb 23: 103 p. (type species).

DIAGNOSIS: Trilete microspore, laesurae simple, equatorial outline triangular, spore body foveolate.

FOVEOTRILETES sp.

Plate 4, Fig. 6.

DESCRIPTION: Trilete, laesurae simple extends to the margin of the spore, equatorial outline triangular, surface covered with foveolate ornamentation, exine thick.

DISTRIBUTION: Recovered from the lower part of the section.

SIZE: Equatorial diameter = 28 microns.

FIGURED SPECIMEN: Pl. 4, fig. 6, slide no. DUN 99-1, Co-ord. 38.7/129.7.

Genus LYCOPODIUMSPORITES Thiergart ex Delcourt and Sprumont, 1955

1938 Lycopodiumsporites agathoecus (Potonie) Thiergart 1938 (type species).

DIAGNOSIS: Trilete, equatorial outline triangular, azonate, laesurae may reach the equator, distal surface reticulate with muri, proximal surface unsculptured.

LYCOPODIUMSPORITES AUSTROCLAVATIDITES (Cookson) Potonie, 1956

Plate 4, Figs. 7, 8

1953 Lycopodium austroclavatidites Cookson, Australian J. Botany, Vol. 1, p. 469, pl. 2, fig. 35.

1953 Lycopodium sp. Couper, New Zealand Geol. Survey, Palaeont. Bull. 22, p. 19, pl. 1, fig. 2.

1959 Lycopodium reticulumsporites Rouse, Micropalaeont., Vol. 5, p. 309, pl. 2, figs. 1-3.

1960 Lycopodium marginatum Kara-Murza, Tr. Nauk-Issl. Invest. Geol. Arctic 54, pl. 16, fig. 2.

1962 Lycopodiumsporites austroclavatidites (Cookson) Pocock, Palaeontographica, Band III, Abt. B, pl. 1, figs. 5, 6.

1964 Lycopodiumsporites austroclavatidites (Cookson) Pocock - Singh,
Res. Coun. Alberta Bull. 15, p. 39, pl. 1, figs. 3, 4.

DESCRIPTION: See Singh (1964), p. 39.

SIZE: Equatorial diameter = 30 microns.

DISTRIBUTION: Jurassic and Lower Cretaceous. Common in
Upper Mesozoic of S. E. Australia. Rare in Dunvegan type section.

FIGURED SPECIMEN: Pl. 4, figs. 7, 8, slide no. DUN 248-3,
Co-ord. 64/126.4.

LYCOPODIUMSPORITES MARGINATUS Singh, 1964

Plate 4, Figs. 9, 10

1964 Lycopodium marginatus Singh, 1964. Res. Coun. Alta, Bull. 15,
p. 41, pl. 1, figs. 7-10.

DESCRIPTION: Trilete, laesurae extending up to $3/4$ of the
spore radius, moderately raised commissures, equatorial outline triangular,
sides strongly convex, distal surface reticulate with polygonal muri,
about 1 micron in diameter, membranous net work present thickened and
rodlike at intersections.

SIZE: Equatorial diameter (including the membranous zone) =
45-60 microns.

DISTRIBUTION: Aptian to M. Albian (East-central Alberta).
Recovered from the upper part of type section.

FIGURED SPECIMEN: Pl. 4, figs. 9, 10, slide no. DUN 213-3,
Co-ord. 66.6/123.4, slide no. DUN 213-2, 63.4/110.5.

Genus LYCOPODIACIDITES Couper emend. Potonie, 1956

- 1953 Lycopodiacidites Couper, N.Z. Geol. Surv. Palaeo. Bull. 22, p. 26.
1956 Lycopodiacidites Couper, emend. Potonie, Jahrb. 23, p. 39.
1961 Iniquiornatisporis Dev, Palaeobotanist 8, p. 44.

DIAGNOSIS: Trilete, laesurae simple, equatorial outline subcircular, azonate, verrucate to rugulate sculpture distally.

REMARKS: Dettmann (1963) also included those spores in this genus, which possessed sculpture on the distal as well on proximal side. However no emendations were proposed. A similar treatment is made in the present work without making any emendations.

Lycopodiacidites can be differentiated from Camarozonosporites by the absence of inter-radial thickenings (Crassitudes) in the latter genus.

LYCOPODIACIDITES sp.

Plate 4, Fig. 12

- 1966 Camarozonosporites rudis (Leschik, 1955) Klans 1960, Hedlund, Okla. Geol. Surv. Bull. 112, p. 17, pl. 3, figs. 3a, b.

DESCRIPTION: Trilete, laesurae simple, reaching the equatorial margin, equatorial outline subtriangular to subcircular, exine verrucate, thick.

SIZE: Equatorial diameter = 30-39 microns.

REMARKS: Similar spores were treated by Hedlund (1966) under Camarozonosporites. There is no indication of a distinct inter-radial thickening in this specimen and thus are treated here under Lycopodiacidites.

DISTRIBUTION: Specimen recovered from the middle and the upper part of type section.

FIGURED SPECIMEN: Pl. 4, fig. 12, slide no. DUN 213-4, Co-ord. 53.2/117.8, DUN 126-3, Co-ord. 53.2/115.

Genus LYCOSPORA Schopf, Wilson and Bentall, 1944

1944 Lycospora micropapillatus (Wilson and Coe) Schopf, Wilson and Bentall, Illinois State Geol. Surv., Rept. Invest. 91, p. 54, pl. 3, figs. 19-19b (type species).

DIAGNOSIS: Trilete, laesurae simple, extending to the margin, cingulum present, equatorial outline circular or semicircular, central body may or may not be ornamented.

LYCOSPORA sp.

Plate 4, Fig. 13

DESCRIPTION: Trilete, laesurae simple slits, reaching the equatorial margin, equatorial outline subcircular, cingulum present, exine verrucate, verrucae broad, irregular, mostly anastomosing.

SIZE: Equatorial diameter - 43 microns.

Thickness of cingulum - 5 microns.

REMARKS: The size difference and lack of thick cingulum differentiates the present specimen from Lycospora sp. described by Singh (1964). Also the lack of thinning of cingulum towards the equatorial margin, and the presence of anastomosing verrucae differentiates the present specimen from Lycospora cretacea Pocock 1962.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 4, fig. 13, slide no. DUN 213-2, Coord. 45.8/118.7.

Genus RETICULATISPORITES (Ibrahim) Schopf, Wilson and Bentall, 1944

- 1932 Sporonites reticulatus Ibrahim, N. Jb., Beil. = B. 67, Abt. B, p. 447, pl. 14, fig. 3 (type species).
- 1933 Reticulatisporites reticulatus Ibrahim, Sporenformen des Aegirhorizonts, p. 31, pl. 5, fig. 36.
- 1944 Reticulatisporites reticulatus (Ibrahim) Schopf, Wilson and Bentall, Ill. Geol. Surv., Rept. 91, p. 34, pl. 1, figs. 7-7b.

DIAGNOSIS: Trilete or alete microspores, equatorial outline circular to subcircular. Exine coarse and irregularly reticulate. In addition to coarse ornamentation, smooth, punctate or finely reticulate texture may be present.

RETICULATISPORITES cf. R. CASTELLATUS Pocock, 1962

Plate 5, Fig. 1

- 1962 Reticulatisporites castellatus Pocock, Palaeontographica Band III, Abt. B, p. 35, pl. 1, fig. 14.

DESCRIPTION: Trilete, laesurae present, equatorial outline subtriangular, exine strongly reticulate, muri high, exine of lumina scabrate, wide and translucent outer edge corrugate, color of spore dark yellow.

SIZE: Equatorial diameter = 32 microns.

REMARKS: The described specimen lack the characteristic castellate outline of the spore, as demonstrated in figure from Pocock (1962, pl. 1, fig. 14).

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 5, fig. 1, slide no. DUN 248-6,
Co-ord. 29.3/125.3.

RETICULATISPORITES sp.

Plate 5, Fig. 1

DESCRIPTION: Trilete, laesurae indistinct, probably reaching the spore margin, equatorial outline circular, proximal and distal exine reticulate, muri 2 microns in thickness, lumina 5 sided and 10 microns wide, scabrate.

SIZE: Equatorial diameter = 46 microns.

DISTRIBUTION: Recovered from upper part of the type section.

FIGURED SPECIMEN: Pl. 5, fig. 2, slide no. DUN 191-1,
Co-ord. 42.5/113.

FAMILY SCHIZAEACEAE

Genus APPENDICISPORITES Weyland and Krieger, 1953

1953 Appendicisporites tricuspidatus Weyland and Greifeld, Palaeontographica, Band 95, Abt. B, p. 42, pl. 11, fig. 54 (type species).

DIAGNOSIS: Trilete, exine two layered, equatorial outline triangular, appendices short and conical, exine covered with broad partially branching ridges more or less parallel to the equatorial sides of the spore.

APPENDICISPORITES ERDTMANII Pocock 1965

Plate 5, Figs. 3, 4

1964 Appendicisporites erdtmanii Pocock (in press) - Singh, Res. Coun. Alberta, Bull. 15, p. 48, pl. 2, figs. 5-7.

1965 Appendicisporites erdtmanii Pocock, Grana Paly. Vol. 5.

DESCRIPTION: See Singh (1964, p. 48).

SIZE: Equatorial diameter - 47 microns.

DISTRIBUTION: Reported by Singh (1964) and Pocock (1965) in Mannville Group of East-Central Alberta and Saskatchewan. Rare in type section.

FIGURED SPECIMEN: Pl. 5, figs. 3, 4, slide no. DUN 248-6, Co-ord. 43.9/129.2.

APPENDICISPORITES PERPLEXUS Singh, 1964

Plate 5, Figs. 5, 6

1964 Appendicisporites perplexus Singh, Res. Coun. Alberta, Bull. 15, p. 55, pl. 5, figs. 6-9.

1967 Contignisporites perplexus (Singh) Norris. Palaeontographica Band 120, Abt. B, p. 98, pl. 14, figs. 1-4.

DESCRIPTION: See Singh (1964, p. 55).

SIZE: Equatorial diameter - 37 microns.

DISTRIBUTION: Middle Albian - Cenomanian. Recovered from the middle part of the type section.

REMARKS: Norris (1967) has transferred this species to genus Contignisporites. This transfer is not justified because genus Contignisporites includes spores having muri across the full length of

the spore body.

FIGURED SPECIMEN: Pl. 5, figs. 5, 6, slide no. DUN 126-2,
Co-ord. 65.7/115.7.

APPENDICISPORITES TRICHACANTHUS (Maljavkina) var. DISSECTUS
(Markova) Singh, 1964

Plate 5, Fig. 7

1961 Anemia tricanthus (Maljavkina) var dissectus Markova, in Samoilovitch
et. al., Trudy vses Neft. Nauch - Issled. Geol. Razv. Inst. Vol. 177,
p. 13, pl. 18, figs. 3a-c.

1964 Appendicisporites trichacanthus (Maljavkina) var. dissectus (Markova)
Singh, Res. Coun. Alberta Bull. 15, p. 51, pl. 3, figs. 1-6.

DESCRIPTION: Trilete, laesurae indistinct probably reaching
up to margin of the endexine in the apices, equatorial outline triangular,
sides moderately concave to slightly straight, ectexine ornamented both
on proximal as well as on distal faces with 5 ribs parallel to the sides,
each about 3 microns apart, ectexine thick at the apices, apices slightly
protruding finger like smooth without any ornamentation, each appendices
about 15 microns long.

SIZE: Equatorial diameter = 54 microns.

REMARKS: This species can be distinguished from A. jansonii
Pocock by its protruding appendices.

DISTRIBUTION: Common.

FIGURED SPECIMEN: Pl. 5, fig. 7, slide no. DUN 191-1,
Co-ord. 63/113.

APPENDICISPORITES TRICORNITATUS Weyland and Greifeld, 1953

Plate 5, Fig. 8

- 1953 Appendicisporites tricornitatus Weyland and Greifeld, Palaeontographica, Band 95, Abt. B, p. 43, pl. 11, Fig. 52.
- 1964 Appendicisporites tricornitatus Weyland and Greifeld - Singh, Res. Coun. Alberta, Bull. 15, p. 46, pl. 2, fig. 1.

DESCRIPTION: See Singh (1964, p. 46).

SIZE: Equatorial diameter - 45 microns.

DISTRIBUTION: Albian - Cenomanian. Rare.

FIGURED SPECIMEN: Pl. 5, fig. 8, slide no. DUN 248-4,

Co-ord. 42.7/112.5.

APPENDICISPORITES UNICUS (Markova) Singh 1964

Plate 5, Figs. 9, 10, 11

- 1961 Appendicisporites unicus Markova in Samoilovitch et. al. Trudy vses. Neft. Nauch. Issled. Geol. - Razv. Inst., Vol. 177, p. 79, pl. 20, figs. 3a, b.
- 1964 Appendicisporites unicus Markova - Singh, Res. Coun. Alberta, Bull. 15, p. 53, pl. 4, figs. 4-6.

DESCRIPTION: See Singh (1964, p. 53).

SIZE: Equatorial diameter 32-43 microns.

Length of Appendices 17-20 microns.

DISTRIBUTION: Albian to Cenomanian. Common in Cenomanian stage of Siberia. Few specimens recovered from the lower and middle part of the type section.

FIGURED SPECIMEN: Pl. 5, figs. 9, 10, 11, slide no. DUN 126-3,

Co-ord. 55.5/125.5.

APPENDICISPORITES sp. A

Plate 5, Fig. 12

DESCRIPTION: Trilete, laesurae indistinct, equatorial outline triangular, sides slightly convex, ectexine ornamented with 4 or 5 ribs each about 2 microns wide, spaced at about 5 microns apart. Apices slightly rounded and broad, smooth without any ornamentation.

SIZE: 52-80 microns.

REMARKS: This species differs from A. crickmayii Pocock, by a lack of distinct margo bordering the laesurae, and in being larger in size.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 5, fig. 12, slide no. 191-1, Co-ord. 68/113.9.

Genus CICATRICOSISPORITES Potonie and Gelletich 1933

- 1933 Cicatricosisporites dorogensis Potonie and Gelletich, Sitzber. Ges. Naturf. Freunde (Berlin), Vol. 33, p. 522, pl. 1, figs. 1-5 (type species).
- 1949 Mohria - Typus, Thiergart, Palaeontographica, Band 89, Abt. B, p. 22.
- 1950 Mohrioidites Thiergart, Geol. Jahrb., Vol. 65, p. 84.
- 1951 Mohriosisporites dorogensis Potonie, Palaeontographica, Band 91, Abt. B, p. 135, pl. 20, fig. 14.
- 1956 Cicatricosisporites australensis (Cookson) Potonie, Beih. Geol. Jahrb., Heft 23, p. 48.
- 1961 Mohria dorogensis (Potonie) Markova, in Samoilovitch et. al. Trudy Vses. Neft. Nauch - Issled. Geol. Razv. Inst., vol. 177, p. 86, pl. 22, fig. 4.

DIAGNOSIS: Trilete, exine two layered and sculptured with

muri or ridges of uniform width and height, cicatricose, muri more or less parallel to the equator. Equatorial outline regular crenulate, with no thickening at the apices.

CICATRICOSISPORITES DOROGENSIS Potonie and Gellertich, 1933

Plate 6, Fig. 1

Synonymy as for genus.

SIZE: 41-65 microns.

DISTRIBUTION: Cretaceous, common in the type section.

FIGURED SPECIMEN: Pl. 6, fig. 1, slide no. DUN 52-4,

Co-ord. 26.2/115.4.

CICATRICOSISPORITES MEDIOSTRIATUS (Bolkhovitina) Pocock, 1962

Plate 6, Fig. 2

- 1961 Pelletieria mediotriatus, Bolkhovitina, Trudy Geol. Inst. Akad. Nauk, SSSR, Vol. 40, p. 66, pl. 19, figs. 3a-b, pl. 21, figs. 1a-c.
- 1965 Cicatricosisporites mediotriatus (Bolkhovitina) Pocock, Grana Palynologica, Vol. 5.
- 1964 Cicatricosisporites mediotriatus (Bolkhovitina) Pocock - Singh, Res. Coun. Alberta, Bull. 15, p. 59, pl. 6, fig. 6.

DESCRIPTION: See Singh (1964, p. 59).

SIZE: 43 microns.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 6, fig. 2, slide no. DUN 213-2,

Co-ord. 55.4/107.5.

CICATRICOSISPORITES MINUTAESTRIATA (Bolkhovitina) comb. nova.

Plate 6, Figs. 3, 4

1961 Pelletieria minutaestriata Bolkhovitina Trudy. Geol. Inst. Akad.,
Nauk SSSR, Vol. 40, p. 68, pl. 20, fig. 1a, pl. 21, figs. 3a-d.

DESCRIPTION: Trilete, laesurae simple extend $3/4$ of spore body, a well developed margo present, equatorial outline sub-triangular, apices broadly rounded, sides fairly convex, exine on proximal and distal side, ornamented with minute ribs, oblique to sides of the spore, proximal - distal orientation of the ribs forms a criss cross pattern, exine thin.

SIZE: Equatorial outline - 60 microns or less.

DISTRIBUTION: This species is found in the Cenomanian sediments of Russia (Bolkhovitina 1961). At "Dunvegan" type area this species is abundant and found in clusters.

REMARKS: This species is put under the organ genus Cicatricosisporites. Russian palynologists treat Cicatricosisporites forms under the living genus Pelletieria.

FIGURED SPECIMEN: Pl. 6, figs. 3, 4, slide no. DUN 248-6,
Co-ord. 48.3/113.7, 28.5/128.2.

CICATRICOSISPORITES sp. A

Plate 6, Fig. 5

DESCRIPTION: Trilete, laesurae simple slits reaching equator, bordered by exinal thickenings, equatorial outline rounded triangular, proximal surface thin and smooth, distal end with two sets of ribs making a "criss cross" pattern, outer margin wavy.

SIZE: Equatorial diameter - 37 microns.

DISTRIBUTION: Rare in the middle part of the type section.

FIGURED SPECIMEN: Pl. 5, fig. 5, slide no. DUN 191-2,

Co-ord. 32.7/122.8.

CICATRICOSISPORITES sp. B

Plate 6, Figs. 6, 7, 8, 9.

DESCRIPTION: Trilete, laesurae simple extends to margin of spore cavity, equatorial outline triangular, sides straight to weakly convex, apices moderately rounded, exine thickened around the spore, muri on proximal side in three sets, more or less parallel to each side of the spore, distal muri bilaterally symmetrical, five in number, muri on proximal and distal end perforated by small holes, muri separated by narrow lumina, 1-3 microns wide.

SIZE: Equatorial diameter - 45 microns.

DISTRIBUTION: Rare in the upper part of the type section.

FIGURED SPECIMEN: Pl. 6, figs. 6, 7, 8, 9, slide no. DUN

248-6, Co-ord. 54.4/116.3.

Genus KLUKISPORITES Couper, 1958

1958 Klukisporites variegatus Couper, Palaeontographica, Band 103, Abt. B, p. 137, pl. 19, figs. 6, 7 (type species).

DIAGNOSIS: Trilete, laesurae $3/4$ of spore radius, raised commissurae, bordered by margo, equatorial outline rounded triangular, distal surface with foveolate or foveo-reticulate pattern, proximal surface with greatly reduced sculpture, exine thick.

KLUKISPORITES sp. A

Plate 6, Fig. 10

DESCRIPTION: Trilete, laesurae $3/4$ of spore radius raised commissurae, equatorial outline rounded triangular, distal surface with foveolate ornamentation, distributed uniformly, proximal surface with reduced sculpture, exine thick, margin wavy.

SIZE: Equatorial diameter - 42 microns.

DISTRIBUTION: Few specimens recovered from the middle part of the type section.

FIGURED SPECIMEN: Pl. 6, fig. 10, slide no. DUN 213-2, Co-ord. 28/118.4.

KLUKISPORITES sp. B

Plate 6, Fig. 11

DESCRIPTION: Trilete, laesurae with a distinct margo equatorial outline rounded triangular, distal surface foveo-reticulate, proximal surface with reduced sculpture, exine thick margin wavy.

SIZE: Equatorial diameter - 58 microns.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 6, fig. 11, slide no. DUN 52-4, Co-ord. 24.8/109.3.

Genus SCHIZAEOSPORITES Potonie, 1951

1944 Schizaea eocenica Selling, Medd. Goteborgs Bot. Tradgard, Vol. 16, p. 66, pl. 4, fig. 44.

1956 Schizaeoisporites eocenicus (Selling) Potonie, Beih. Geol. Jahrb. Heft. 23, p. 81, pl. 1, fig. 108 (type species).

DIAGNOSIS: Monolete spores, cicatriocose exine, laesurae has a ridge on either side.

SCHIZAEOSPORITES EOCENICUS (Selling) Potonie, 1956

1964 Schizaeoisporites eocenicus (Selling) Potonie - Singh, Res. Coun. Alberta Bull. 15, p. 62, pl. 7, figs. 8, 9.

Plate 6, Fig. 12

DESCRIPTION: See Singh (1964, p. 62).

SIZE: Length 39-53 microns.

DISTRIBUTION: Lower Cretaceous to Eocene. Rare in 'Dunvegan' type section.

FIGURED SPECIMEN: Pl. 6, fig. 12, slide no. DUN 248-1, Co-ord. 45.5/119.1.

FAMILY GLEICHENIACEAE

Genus GLEICHENIIDITES Ross ex (Delcourt and Sprumont)
Dettmann, 1963

- 1949 Gleicheniidites senonicus Ross, Bull. Geol. Inst. Univ. Upsala, Vol. 34, p. 31, pl. 1, figs. 3, 4 (type species).
- 1955 Gleicheniidites senonicus Ross ex Delcourt and Sprumont, Mem. Soc. Geol. Belgique, N.S., Vol. 4, p. 26.
- 1961 Gleichenia senonica (Ross) Grigorjeva, in Samoilovitch et. al. Trudy Vses. Neft. Nauch - Issled. Geol. - Razv. Inst., Vol. 177, p. 46, pl. 13, figs. 1a-b, 2a-b, 3a-b.

DIAGNOSIS: Trilete, equatorial outline triangular, exine smooth with exinal thickenings in each equatorial inter-radial region.

AFFINITY: The spores of modern Gleichenia circinata Swartz and G. laveissima Christ, are comparable morphologically to Gleicheniidites.

GLEICHENIIDITES SENONICUS Ross 1949

Plate 6, Figs. 13, 14

(Synonymy as for genus)

DESCRIPTION: Trilete, laesurae simple reaching the equator, equatorial outline triangular, apices arcuate, sides concave, proximal face flat, distal face strongly convex, proximal distal flattening results in three folds on the distal side, exine smooth.

SIZE: Average equatorial diameter - $21\frac{3}{4}$ microns.

DISTRIBUTION: Abundant in Jurassic and Cretaceous; abundant throughout the type section.

REMARKS: The degree of concavity, and the intensity of flattening varies from specimen to specimen.

FIGURED SPECIMEN: Pl. 6, figs. 13, 14, slide no. DUN 191-1, Co-ord. 51.5/111.4.

FAMILY MARATTIACEAE

Genus MARATTISPORITES Couper, 1958

1958 Marattisporites scabratus Couper, Palaeontographica, Vol. 103, Abt. B, p. 133, pl. 15, figs. 20-23 (type species).

DIAGNOSIS: Monolete, laesurae long, shape variable, elliptical to spherical, exine 1 micron thick, finely granular to scabrate; greatest dimension less than 35 microns.

REMARKS: The genus Marattisporites can be distinguished from Punctatosporites by the presence of sparsely placed granules on the spore body. The genus Punctatosporites has closely spaced granules on the spore body.

MARATTISPORITES ROUSEI Srivastava, 1966

Plate 6, Fig. 15

1966 Marattisporites rousei Srivastava, Poll. et Spo. Vol. 8, No. 3, p. 504, pl. 4, figs. 5, 6.

DESCRIPTION: See Srivastava (1966, p. 504).

SIZE: 30-40 microns.

DISTRIBUTION: Reported in Upper Cretaceous of Alberta, common in type section.

FIGURED SPECIMEN: Pl. 6, fig. 15, slide no. DUN 126-3, Co-ord. 38.7/117.3.

FAMILY CYATHEACEAE

Genus CYATHIDITES Couper 1953

1953 Cyathidites australis Couper, New Zealand Geol. Surv. Paleon. Bull. 22, p. 27, pl. 2, figs. 11, 12 (type species).

DIAGNOSIS: Trilete, laesurae over $2/3$ of the radius of spore, equatorial outline triangular, apices rounded, sides concave, proximal face moderately convex, distal face broadly convex, exine smooth or faintly patterned.

REMARKS: Cyathidites is distinguished from Deltoidospora Miner, by the presence of straight sides in the latter genus, while Leiotriletes Naumova ex Potonie and Kremp has convexly triangular sides. The genus Concavisporites Pflug can be differentiated from the above mentioned genera, by the presence of krytomes.

AFFINITY: Couper (1953, 1958) advocated affinity of Cyathidites

with Cyatheaceous and Dicksoniaceae forms, while Russian workers have shown that other species now included within Cyathidites are comparable to modern genus Lygodium Swartz (Dettmann 1963).

CYATHIDITES AUSTRALIS Couper, 1953

Plate 6, Fig. 16

(Synonymy as for genus)

1964 Cyathidites australis Couper - Singh, Res. Coun. Alberta, Bull. 15, p. 70, pl. 8, fig. 12.

DESCRIPTION: See Singh (1964, p. 70).

SIZE: Equatorial diameter - 52 microns.

DISTRIBUTION: Common in the middle and the upper part of the type section.

FIGURED SPECIMEN: Pl. 6, fig. 16, slide no. DUN 126-4, Co-ord. 39.5/128.

CYATHIDITES MINOR Couper, 1953

Plate 7, Fig. 1

1953 Cyathidites minor, New Zealand., Geol. Surv. Paleont. Bull. 22, p. 28, pl. 2, fig. 13.

DESCRIPTION: See Singh (1964, p. 71).

SIZE: Equatorial diameter 23 microns.

DISTRIBUTION: Jurassic and Cretaceous. Common in the type section.

FIGURED SPECIMEN: Pl. 7, fig. 1, slide no. DUN 191-2, Co-ord. 59/122.8.

Order FILICALES - INCERTAE SEDIS

Genus BACULATISPORITES Thomson and Pflug, 1953

- 1953 Baculatisporites primarius (Wolff 1934, p. 66, Taf. 5, fig. 8, Zeichnung nach Prap XVI 50 in Berlin). Thomson and Pflug, Palaeontographica, vol. 94B, p. 56 (type species).
- 1953 Triletes commaumensis Cookson, Aust. J. Bot., Vol. 1, no. 3, p. 470, pl. 2, figs. 27, 28.
- 1953 Baculatisporites primarius (Wolff) Thomson and Pflug, Palaeontographica, vol. 94B, p. 56, Taf. 2, figs. 49-53.

DIAGNOSIS: Trilete, laesurae reach equatorial margin, equatorial outline circular, exine thin with baculate ornamentation.

REMARKS: The genus Baculatisporites can be distinguished from Osmundacidites by the presence of baculate ornamentation. The genus Osmundacidites has granulate ornamentation.

BACULATISPORITES cf. B. COMMAUMENSIS (Cookson) Potonie, 1956

Plate 7, Fig. 2

- 1965 Baculatisporites cf. B. commaumensis (Cookson) Potonie - Srivastava, p. 56, pl. 2, fig. 13. M.Sc. thesis (unpublished) Univ. of Alberta.

DESCRIPTION: See Srivastava (1965, p. 56).

SIZE: 47 microns.

DISTRIBUTION: Cretaceous and Tertiary, common in the type section.

FIGURED SPECIMEN: Pl. 7, fig. 2, slide no. DUN 126-2,

Co-ord. 43.2/117.7.

Genus CAMAROZONOSPORITES (Potonie) Klaus, 1960

- 1953 Rotaspora cretacea Weyland and Krieger, Palaeontographica, Vol. 95, p. 12, pl. 3, fig. 27.
- 1956 Camarozonosporites (Rotaspora) cretaceus (Weyland and Krieger) Potonie, Jahrb. Geol. Beih, Vol. 23, p. 65, (type species).

DIAGNOSIS: Trilete microspore, laesurae simple, exine rugose inter-radial crassitudes present.

CAMAROZONOSPORITES RUDIS (Leschik) Klaus, 1955

Plate 7, Figs. 3, 4

- 1955 Camarozonosporites rudis Leschik, Mem. Suisses. Palaont., Vol. 72, p. 15, pl. 1, fig. 15.
- 1960 Camarozonosporites rudis (Leschik) Klaus, Geol. Band. Jahrb. Sond. 5, p. 136, pl. 29, figs. 12, 14.
- 1961 Rugutriletes rugosus Pierce, Minn. Geol. Surv. Bull. 42, p. 31, pl. 1, fig. 23.

DESCRIPTION: Trilete microspore, laesurae simple exine rugose, inter-radial thickenings present.

SIZE: $3\frac{1}{4}$ microns.

DISTRIBUTION: Upper Cretaceous. Reported from Cenomanian formations, recovered from the middle part of the type section.

FIGURED SPECIMEN: Pl. 7, figs. 3, 4, slide no. DUN 213-3, Co-ord. 63.2/122.3.

Genus CINGUTRILETES Pierce emend. Dettmann, 1963

- 1961 Cingutriletes congruens Pierce, Minn. Geol. Survey, Bull. 42, p. 25, pl. 1, fig. 1 (type species).

1963 Cingutritetes Pierce emend. Dettmann, 1963. Proc. Roy. Soc. Vict. Vol. 77, part 1.

DIAGNOSIS: Trilete microspore, cingulate; equatorial outline subcircular to circular, exine almost smooth.

REMARKS: The genera Cingutritetes and Anulatisporites Loose ex Potonie and Kremp, are morphologically similar forms. The genus Cingutritetes has been retained by Dettmann (1963) for the Mesozoic and Tertiary forms. The genus Anulatisporites includes Paleozoic forms. This distinction on stratigraphic occurrence is a clear departure from the concept of morphospecies.

CINGUTRILETES CLAVUS (Balme) Dettmann, 1963

Plate 7, Fig. 5

1957 Sphagnites clavus Balme, C.S.I.R.O. Aust., Coal Res. Sect. T.C. 25: p. 16, pl. 1, figs. 4-6.

1959 Sphagnumsporites clavus (Balme) De Jersey, Qd. Govt. Min. J. 60, p. 348, pl. 1, fig. 2.

1963 Cingutritetes clavus (Balme) Dettmann, Proc. Roy. Soc. Vic. Vol. 77, part 1, p. 69, pl. 14, figs. 5-8.

DESCRIPTION: Trilete, laesurae extends up to the margin of spore cavity, equatorial outline subtriangular to subcircular, apices fairly rounded, spore cavity enclosed by a wide, radially striated cingulum, proximal exine thick and smooth but corroded, distal exine probably thickened.

SIZE: 24-27 microns.

DISTRIBUTION: This species is common in Jurassic Cretaceous and Tertiary sediments of Australia. Rare.

FIGURED SPECIMEN: Pl. 7, fig. 5, slide no. DUN 248-6,
Co-ord. 54/119.

Genus CONCAVISSIMISPORITES Delcourt and Sprumont, 1955, emend.
Delcourt, Dettmann and Hughes, 1963

- 1955 Concavissimisporites verrucosus Delcourt and Sprumont, Mem. Soc. Geol. Belgique, N.S. Vol. 4, p. 25, pl. 2, fig. 1a (type species).
1963 Concavissimisporite verrucosus Delcourt and Sprumont, emend. Delcourt et. al. Palaeont., Vol. 6, p. 285, pl. 42, figs. 5-7.

DIAGNOSIS: Microspores trilete, outline triangular, sides concave to straight. Exine uniformly thick, sub-granulose to verrucose, granules or verrucae more or less uniformly developed.

REMARKS: Concavissimisporites can be distinguished from Concavisporites by the presence of kryptomes and smooth surface in the latter genus.

CONCAVISSIMISPORITES PUNCTATUS (Delcourt and Sprumont) Singh 1964.

Plate 7, Fig. 6

- 1955 Concavisporites punctatus Delcourt and Sprumont, Mem. Soc. Geol. Belgique N.S., Vol. 4, p. 25, pl. 1, fig. 8, pl. 2, fig. 2.
1958 Concavisporites punctatus Delcourt and Sprumont - Couper, Palaeontographica, Band 103, Abt. B, p. 142, pl. 22, figs. 1-3.
1962 Concavisporites punctatus Delcourt and Sprumont - Pocock, Palaeontographica, Band III, Abt. B, p. 46, pl. 5, fig. 72.
1963 Cyathidites punctatus (Delcourt and Sprumont) Delcourt et. al. Palaeont., Vol. 6, p. 283, pl. 42, figs. 1-4.
1963 Cyathidites punctatus (Delcourt and Sprumont) Delcourt, Dettmann and Hughes, Dettmann, Proc. Roy. Soc. Vict. Vol. 77, part 1, p. 23, pl. 1, figs. 6-9.
1964 Concavissimisporites punctatus (Delcourt and Sprumont) Singh. Res. Coun. Alberta, Bull. 15, p. 77, pl. 9, figs. 6, 7.

- 1966 Cyathidites punctatus (Delcourt and Sprumont) Delcourt et. al. - Hedlund. Okla. Geol. Surv. Bull. 112, p. 11, pl. 2, figs. 3a, b.

DESCRIPTION: See Singh (1964, p. 77).

SIZE RANGE: Equatorial diameter - 80 microns.

DISTRIBUTION: This species has a wide geographical distribution. Reported from Wealden of Belgium (Delcourt and Sprumont, 1955), Wealden and Aptian of United Kingdom (Couper 1958), Upper Mesozoic of Australia, (Dettmann 1963), Potomac Group of Maryland (Leopold and Pakiser 1964), Lower Cretaceous of Alberta (Pocock 1962, Singh 1964). Common in the middle part of the type section.

REMARKS: The transfer of Cyathidites punctatus to Concavissimisporites is retained here, on the basis of an undulose appearance of the surface as suggested by Singh (1964, p. 78). The genus Cyathidites includes the psilate forms.

FIGURED SPECIMEN: Pl. 7, fig. 6, slide no. DUN 191-4, Co-ord. 62.1/119.6.

CONCAVISSIMISPORITES PARKINII (Pocock) Singh 1964

Plate 7, Fig. 7

- 1962 Concavisporites parkinii Pocock, Palaeontographica, Band III, Abt. B, p. 46, pl. 4, fig. 71.

- 1964 Concavissimisporites parkinii (Pocock) Singh, Res. Coun. Alberta, Bull. 15, p. 78.

DESCRIPTION: See Singh (1964, p. 78).

SIZE: Equatorial diameter - 55-85 microns.

DISTRIBUTION: Cretaceous, rare in Dunvegan type area.

FIGURED SPECIMEN: Pl. 7, fig. 7, slide no. DUN 99-1, Co-ord. 34.3/114.1.

CONCAVISSIMISPORITES VARIVERRUCATUS (Couper) Singh, 1964

Plate 7, Fig. 8

- 1958 Concavissimisporites variverrucatus Couper, Palaeontographica, Band 103, Abt. B, p. 142, pl. 22, figs. 4, 5.
- 1964 Concavissimisporites variverrucatus (Couper) Singh 1964, Res. Coun. Alta. Bull. 15, p. 78, pl. 9, figs. 9-11.

DESCRIPTION: See Singh (1964, p. 78).

SIZE RANGE: Equatorial diameter 63 microns.

DISTRIBUTION: Cretaceous, few specimens were recovered from the middle part of the type section.

FIGURED SPECIMEN: Pl. 7, fig. 8, slide no. 191-7, Co-ord. 43.2/119.7.

Genus CONCAVISPORITES Pflug, 1953

- 1953 Concavisporites regulatus Pflug, Palaeontographica, Vol. 94B, p. 49, pl. 1, fig. 22.

DIAGNOSIS: Trilete, equatorial outline triangular, sides more or less concave, proximo-distal compression of the tetrad may result in folding of inter apical and apical parts.

CONCAVISPORITES sp.

Plate 7, Figs. 9, 10

DESCRIPTION: Trilete, laesurae simple, extend to the margin of spore, equatorial outline triangular, apices arcuate, sides concave, proximal face flat, distal face convex, proximo-distal compression of tetrad resulting in folding of inter apical and apical parts, exine smooth.

SIZE: Equatorial diameter - 21 microns.

DISTRIBUTION: Common in the middle parts of the type section.

FIGURED SPECIMEN: Pl. 7, figs. 9, 10, slide no. DUN 191-3,
Co-ord. 65.5/116.4.

Genus COOKSONITES Pocock emend. Dettmann, 1963

1962 Cooksonites variabilis Pocock, Palaeontographica Band III, Abt. B,
p. 54, pl. 7, figs. 112-117 (type species).

DIAGNOSIS: Microspore alete or trilete, exine thick, two
layered, comprising a central body enclosed by a thick patella. The
patella is thickest at the equator, and thins towards the proximal pole
and may or may not possess bands of differential thickening.

REMARKS: Dettmann (1963) emended the genus, by placing
group II of the genus Cooksonites Pocock (1962) in genus Coptospora.
Thus genus Cooksonites includes group I only.

COOKSONITES cf. C. VARIABILIS Pocock, 1962

Plate 7, Fig. 11

DESCRIPTION: Trilete, laesurae $1/2$ of the radius of spore,
indistinct, equatorial outline circular to subcircular, exine two
layered; thick ectexine layer covering the proximal surface and probably
extends to distal side, bands of somewhat differential thickening visible
on the proximal surface, faintly visible polygonal surface on distal
surface, central body small, surrounding the distal pole, exine thick
and brown.

SIZE: Equatorial diameter 47 microns.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 7, fig. 11, slide no. DUN 213-1,

Co-ord. 37.4/114.7.

Genus DELTOIDOSPORA Miner, 1935, emend. Potonie, 1956

- 1935 Deltoidospora halli Miner, Am. Midland Naturalist, Vol. 16, p. 618, pl. 24, fig. 7.
- 1956 Deltoidospora halli Miner, emend. Potonie, Beith, Geol. Jahrb., Heft 23, p. 13, pl. 1, fig. 1 (type species).
- 1964 Deltoidospora halli Miner, emend. Potonie - Singh, Res. Coun. Alberta, Bull. 15, p. 80, pl. 9, figs. 13, 14.

DIAGNOSIS: Trilete, laesurae simple, more than $2/3$ of spore radius, equatorial outline triangular with rounded apices, sides straight, may be slight convex to concave, exine smooth.

REMARKS: Deltoidospora differs from genus Cyathidites Couper (1953) by its deltoid shape and thick exine. Cyathidites has concave sides and thin exine.

DELTOIDOSPORA DIAPHANA Wilson and Webster, 1946

Plate 7, Fig. 12

- 1946 Deltoidospora diaphana Wilson and Webster, Am. Jour. Bot. Vol. 33, No. 4, p. 271-278, figs. 1-18.

DESCRIPTION: Trilete, laesurae slightly raised, extends almost to the spore radius, equatorial outline rounded triangular, apices broad and rounded, exine with differential thickening.

SIZE: Equatorial diameter - 41 microns.

DISTRIBUTION: Reported from Paleocene, Fort Union Formation

of Montana. Rare in 'Dunvegan' type area.

FIGURED SPECIMEN: Pl. 7, fig. 12, slide no. 191-9,
Co-ord. 54.4/118.5.

DELTOIDOSPORA HALLI Miner, 1935

Plate 7, Fig. 13

(Synonymy as for genus)

DESCRIPTION: See Singh (1964, p. 80).

SIZE: Equatorial diameter - 28 microns.

DISTRIBUTION: Jurassic, Cretaceous.

FIGURED SPECIMEN: Pl. 7, fig. 13, slide no. DUN 191-1,
Co-ord. 33/43.

DELTOIDOSPORA PSILOSTOMA Rouse 1959

Plate 7, Fig. 14

1959 Deltoidospora psilostoma Rouse micropaleont., Vol. 5, p. 311, pl. 2,
figs. 7, 8.

1964 Deltoidospora psilostoma Rouse - Singh, 1964. Res. Coun. Alta.
Bull. 15, p. 80, pl. 9, fig. 15.

DESCRIPTION: See Singh (1964, p. 80).

SIZE: Equatorial diameter - 28 microns.

DISTRIBUTION: Upper Jurassic to Upper Cretaceous.

FIGURED SPECIMEN: Pl. 7, fig. 14, slide no. 191-1, Co-ord.
60.5/117.6.

DELTOIDOSPORA sp.

Plate 7, Fig. 15

DESCRIPTION: Trilete, laesurae extend $2/3$ of the spore radius, equatorial outline triangular, a triangular opening in the centre, exine thickened around trilete opening, ornamentation infra punctate (+ smooth).

SIZE: Equatorial diameter = 39-43 microns.

REMARKS: A similar species was recorded by Srivastava (1966) from the Upper Cretaceous of Alberta.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 7, fig. 15, slide no. DUN 213-2,
Co-ord. 35.9/125.8.

Genus GRANULATISPORITES Ibrahim, 1933 emend.
Potonie and Kremp, 1954

- 1933 Granulatisporites granulatus Ibrahim, doctor diss., Tech. Hochschule Zu Berlin (privately published), pl. 6, fig. 51 (type species).
1955 Granulatisporites granulatus Ibrahim, emend. Potonie and Kremp, Palaeontographica, Band 98, Abt. B, p. 56, pl. 12, figs. 157-160.

DIAGNOSIS: Trilete, subtriangular, exine densely granulose spherical and almost of equal size.

GRANULATISPORITES sp.

Plate 7, Fig. 16

DESCRIPTION: Trilete, commissures moderately raised, reaching the equator, equatorial outline triangular with moderately convex to slightly

concave sides, exine granulose particularly pronounced towards the peripheral area, margin wavy.

SIZE: Equatorial diameter = 30-40 microns.

REMARKS: Granulatisporites sp. Singh 1964, (p. 98) differs from the above species by densely granulose ornamentation and slightly convex sides.

DISTRIBUTION: Few specimens recovered from the middle part of the type section.

FIGURED SPECIMEN: Pl. 7, fig. 16, slide no. DUN 191-1, Co-ord. 27.5/111.1.

Genus HYMENOZONOTRILETES Naumova, 1937 ex Naumova, 1953

1937 Hymenozonotriletes Naumova, Intern. Geol. Congr. 17th, Moscow, Abst. Papers, p. 60-61.

1953 Hymenozonotriletes polyacanthus Naumova, Trudy Inst. Geol. Nauk, Akad. Nauk S.S.S.R. vol. 143, p. 27, pl. 4, fig. 11 (type species).

DIAGNOSIS: Trilete microspores with a zona, equatorial outline subtriangular, exine covered with cones or spines.

HYMENOZONOTRILETES PSEUDOALVEOLATUS (Couper) Singh, 1964

Plate 8, Fig. 1

1958 Cingulatisporites pseudoalveolatus Couper, Palaeontographica, Band 103, Abt. B, p. 147, pl. 25, figs. 5, 6.

1964 Hymenozonotriletes pseudoalveolatus (Couper) Singh, Res. Coun. Alta. Bull. 15, p. 83, pl. 10, figs. 1-3.

DESCRIPTION: See Singh (1964, p. 83).

SIZE: Equatorial outline 45 microns (including zona).

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 8, fig. 1, slide no. DUN 126-5,

Co-ord. 34.5/126.5.

Genus LAEVIGATOSPORITES Ibrahim, 1933, emend. Schopf,
Wilson and Bentall, 1944

1933 Laevigato-sporites vulgaris (Ibrahim) Ibrahim, 1933, doctor diss.,
Tech. Hochschule Zu Berlin (private publication), p. 39-40, pl. 2,
fig. 16 (type species.)

DIAGNOSIS: Monolete, equatorial outline ovoid, meridional
outline bean shaped, smooth exine without any sculpture.

AFFINITY: As noted by Singh (1964) monolete bean shaped
forms indicate a close resemblance with the families Polypodiaceae and
Dennstaedtiaceae.

LAEVIGATOSPORITES OVATUS Wilson and Webster, 1946

Plate 8, Fig. 2

1957 Laevigatosporites ovatus Wilson and Webster - Rouse, Can. J. Botany,
vol. 35, p. 355, pl. 1, fig. 3.

DESCRIPTION: Monolete, suture 1/2 of spore length, gaping,
bean shaped, exine smooth.

SIZE: 39-50 microns.

DISTRIBUTION: Jurassic and Cretaceous. Common in the type
section.

FIGURED SPECIMEN: Pl. 8, fig. 2, slide no. DUN 191-1,

Co-ord. 64.2/111.

Genus LEPTOLEPIDITES Couper, 1953

1953 Leptolepidites verrucatus Couper, N.Z. Geol. Surv. Pal. Bull. 22, p. 77, (type species).

DIAGNOSIS: Trilete microspores, equatorial outline triangular to circular, ornamentation verrucose.

LEPTOLEPIDITES cf. L. VERRUCATUS Couper, 1953

Plate 8, Fig. 3

DESCRIPTION: Trilete microspore, equatorial outline triangular to circular, ornamentation verrucose, exine moderately thick.

SIZE: Equatorial diameter ~ 45 microns.

REMARKS: This species shows smaller and more closely spaced verrucae in contrast to larger verrucae of L. verrucatus.

DISTRIBUTION: Lower and Upper Cretaceous, rare in the type section.

FIGURED SPECIMEN: Pl. 8, fig. 3, slide no. DUN 191-5, Co-ord. 56.8/120.5.

Genus MICRORETICULATISPORITES Knox, 1950 emend.
Potonie and Kremp 1954

1955 Microreticulatisporites lacunosus Knox emend. Potonie and Kremp. Palaeontographica Band 98, Abt. B, p. 96, figs. 24, 25 (type species).

DIAGNOSIS: Trilete, equatorial outline circular to triangular, margin crenulate, exine extra reticulate with small lumina having diameters not more than 6 microns, muri branched or unbranched, variable in length.

AFFINITY: Knox (1950) noted a close resemblance of the genus

Microreticulatisporites with the genus Noeggerathiales.

MICRORETICULATISPORITES sp.

Plate 8, Fig. 4

DESCRIPTION: Trilete, laesurae extend $3/4$ of spore radius, equatorial outline rounded triangular, proximal surface flat, distal surface convex, reticulate, muri and lumen less than 3 microns in diameter margin crenulate, exine thick.

SIZE: Polar length - 47 microns.

REMARKS: This species resembles Microreticulatisporites uniformis Singh, 1964.

DISTRIBUTION: A single specimen recovered from the middle part of the type section.

FIGURED SPECIMEN: Pl. 8, fig. 4, slide no. 213-3, Co-ord. 67.6/117.2.

Genus ROUSEISPORITES Pocock 1962

1962 Rouseisporites reticulatus Pocock, Palaeontographica, Band III, Abt. B, p. 53, pl. 7, figs. 101-105 (type species).

DIAGNOSIS: Alete or trilete, equatorial outline convex triangular with an equatorial flange, laesurae may or may not be present. Some apical extensions penetrated by holes which may or may not visibly penetrate the central body, distal surface with muroid ridges which may anastomose to form a reticulum, proximal surface reticulate or smooth.

ROUSEISPORITES RADIATUS Dettmann 1963

Plate 4, Fig. 5

- 1958 Divisisporites euskirchenensis Cookson and Dettmann, Proc. Roy. Soc. Vict. 70, p. 98, pl. 14, fig. 1.
- 1963 Rouseisporites radiatus Dettmann, Proc. Roy. Soc. Vict. vol. 77, part 1, p. 98, pl. 23, figs. 13-17.

DESCRIPTION: Trilete, laesurae faintly developed, equatorial outline circular to convexly triangular, exine two layered, inner layer 2 - 2.5 microns thick, faintly scabrate, out layer membraneous, zonate, smooth proximally, six radially developed muroid ridges on distal side, narrow zona with conical invagination, about 3 microns in diameter.

SIZE: 54 microns.

DISTRIBUTION: Reported from L. Cretaceous of Australia (Dettmann 1963). Common in the type section.

FIGURED SPECIMEN: Pl. 8, fig. 5, slide no. DUN 191-3, Co-ord. 57.5/126.1.

ROUSEISPORITES RETICULATUS Pocock 1962

Plate 8, Fig. 6

- 1964 Rouseisporites reticulatus Pocock - Singh, Res. Coun. Alberta, Bull. 15, p. 90, pl. 11, figs. 16, 5.

DESCRIPTION: See Singh (1964, p. 90).

SIZE: Equatorial diameter - 60-70 microns.

DISTRIBUTION: Reported occurrences are mostly from Barremani, Aptian and Albian of Australia, Canada and Russia (see Dettmann 1963). However, Dettmann (1963) reported from Winton Formation (Cenomanian of Australia). Common in the type section.

FIGURED SPECIMEN: Pl. 8, fig. 6, slide no. 99-2, Co-ord.

60.1/124.9, 59.3/114.9.

Genus STAPLINISPORITES Pocock 1962

- 1957 Cingulatisporites caminus (Balme) Australia C.S.I.R., Coal Res. Sect. Ref. T. C. 25, p. 27, pl. 5, figs. 62, 63.
- 1962 Staplinisporites caminus (Balme) Pocock, Pocock, Palaeontographica, Band III, Abt. B, p. 49, pls. 5, 6, figs. 87-90 (type species).
- 1964 Staplinisporites caminus (Balme) Pocock-Singh, Res. Coun. Alberta, Bull. 15, p. 84, pl. 11, figs. 1-4.

DIAGNOSIS: Trilete, raised commissures, equatorial outline rounded triangular, proximal exine thin, smooth or granulose, distal surface ornamented by concentric and radial bands of exinal thickenings, distal pole carries a thickened boss which may become detached leaving a granulose area.

STAPLINISPORITES CAMINUS (Balme) Pocock 1962

Plate 8, Fig. 7

(Synonymy as for genus)

DESCRIPTION: See Singh (1964, p. 85).

SIZE: 41 microns.

DISTRIBUTION: Lower Cretaceous of Alberta and Oxfordian to Aptian in Australia (Dettmann 1963). Rare.

FIGURED SPECIMEN: Pl. 8, fig. 7, slide no. DUN 213-3,
Co-ord. 49.3/123.4.

Genus TRILOBOSPORITES Pant nom. nud ex Potonie 1956

- 1954 Concavisporites hannonicus Delcourt and Sprumont, Mem. Soc. Geol. Belgique, N.S., vol. 4, p. 24, pl. 2, fig. 3.
- 1956 Trilobosporites hannonicus (Delcourt and Sprumont) Potonie, Beih. Geol. Jahrb., Heft 23, p. 55, pl. 7, fig. 68 (type species).

DIAGNOSIS: Trilete, equatorial outline triangular, sides concave, apices well rounded, exine verrucate.

REMARKS: The verrucate exine in genus Trilobosporites, distinguishes it from the azonate verrucate forms of Concavissimisporites Delcourt and Sprumont and valvate laevigate spores of Matisporites Couper.

AFFINITY: Most of the workers from Europe and Canada have assigned comparable species to Trilobosporites, but some Russian workers have assigned such spores to Lygodium Swartz.

TRILOBOSPORITES MINOR Pocock, 1962

Plate 8, Fig. 8

- 1962 Trilobosporites minor Pocock, Palaeontographica, Band III, Abt. B, p. 44, pl. 4, figs. 61, 62.
- 1964 Trilobosporites minor Pocock - Singh, Res. Coun. Alberta, Bull. 15, p. 74, pl. 9, fig. 3.

DESCRIPTION: See Singh (1964, p. 74).

SIZE: 20-30 microns.

REMARKS: The laesurae extend almost up to the equatorial margin in the figured specimen.

DISTRIBUTION: Cretaceous, occurs in lower part of the type section.

FIGURED SPECIMEN: Pl. 8, fig. 8, slide no. DUN 99-E, Co-ord. 38.7/117.7.

TRILOBOSPORITES MARYLANDENSIS Brenner, 1963

Plate 8, Fig. 9

1963 Trilobosporites marylandensis Brenner, Dept. Geol. Min. and Waters, Bull. 27, p. 71, pl. 23, fig. 5.

DESCRIPTION: Trilete, laesurae $3/4$ of spore radius, equatorial outline triangular with concave sides and semi rounded apices, exine ornamented with tubercles, which attain larger dimensions and irregular shape at the apices, and seem to develop into reticulate sculpture.

SIZE: Equatorial diameter = 60 microns.

DISTRIBUTION: Reported by Brenner (1963) from Maryland (Potomac Group). Rare, a single specimen was recovered from the middle part of the type section.

FIGURED SPECIMEN: Pl. 8, fig. 9, slide no. DUN 126-2, Co-ord. 42.8/118.8.

TRILOBOSPORITES TRIORETICULOSUS Cookson and Dettmann, 1958

Plate 8, Fig. 10

1958 Trilobosporites trioreticulosus Cookson and Dettmann, Proc. Roy. Soc. Victoria, N.S., Vol. 70, pt. 2, p. 109, pl. 17, figs. 1-3.

1961 Lygodium trioreticulosus (Cookson and Dettmann) Bolkhovitina, Trudy Geol. Inst., Akad. Nauk S.S.S.R., Vol. 40, p. 100, pl. 35, figs. 5a-d, pl. 38, fig. 8.

DESCRIPTION: Trilete, equatorial outline triangular, apices broadly rounded, laesurae about $3/4$ the radius of spore, apices ornamented with reticulum consisting of rounded lumina and muri, surface scabrate.

SIZE: Equatorial diameter = 44-70 microns.

DISTRIBUTION: Cookson and Dettmann (1958) reported from

Aptian to Albian of Australia. Also abundant in Lower Cretaceous of Central Alberta Singh (1964). Common in the Upper part of the type section.

FIGURED SPECIMEN: Pl. 8, fig. 10, slide no. DUN 248-6,
Co-ord. 44.6/114.

Trilete spore

Plate 8, Fig. 11

DESCRIPTION: Trilete, laesurae raised, extend to the spore margin, bifurcate at the end, equatorial outline triangular, sides concave, apices rounded, small membranous zone around central portion of spore, visible at the concave sides, exine smooth and fairly thin.

SIZE: 32 microns.

FIGURED SPECIMEN: Pl. 8, fig. 11, slide no. DUN 191-1,
Co-ord. 27.2/111.

INCERTAE SEDIS

Genus SCHIZOSPORIS Cookson and Dettmann, 1959

1959 Schizosporis reticulatus Cookson and Dettmann, Micropaleont. Vol. 5, p. 213, pl. 1, figs. 1-4 (type species).

DIAGNOSIS: Microspores large with an equatorial furrow along which the spore splits into two parts.

SCHIZOSPORIS PARVUS Cookson and Dettmann 1959

Plate 8, Figs. 12, 13, 14

- 1959 Schizosporis parvus Cookson and Dettmann, Micropaleont., Vol. 5, p. 216, pl. 1, figs. 15-20.
- 1964 Schizosporis parvus Cookson and Dettmann - Singh, Res. Coun. Alberta, Bull. 15, p. 101, pl. 13, fig. 15.

DESCRIPTION: See Singh (1964, p. 101).

SIZE: Max. length = 106 microns.

Max. breadth = 60 microns.

DISTRIBUTION: Pocock (1962) and Singh (1964) recorded from Mannville sediments of central Alberta. This reported presence is based on one or few specimens. The abundance of this species seems to be post Albian in Western Canada. In the present study this species shows its peak or abundance in the upper part of the Dunvegan type section.

Cookson and Dettmann (1959) reported in Albian and ? Cenomanian of Eastern Australia. Clarke (1963) reported from Upper Cretaceous Vermejo Formation of Colorado. Hedlund (1966) reported from Woodbine Formation (Cenomanian) Oklahoma.

REMARKS: The 'Dunvegan' specimens are longer and wider than those reported by earlier workers. Hedlund (1966) named a new species Schizosporis majusculus exclusively on the basis of size. (Holotype 147.5 x 48.6 microns). The 'Dunvegan' specimens have been put in Schizosporis parvus because merely somewhat larger size does not warrant the creation of a new species.

FIGURED SPECIMEN: Pl. 8, figs. 12, 13, 14, slide no. DUN 191-1, Coord. 38.2/119.1, 41/122.5, 30.9/123.4, 63.6/124.1, 50.8/126.1, 60.3/126.1.

SCHIZOSPORIS sp. A

Plate 8, Fig. 15

DESCRIPTION: Spores biconvex, flattened slightly at the poles, elliptical in equatorial view, splitting equatorially into two parts, exine thin, baculate.

SIZE: Length - 56 microns.

REMARKS: The specimen figured has a small split in addition to two equatorial splittings. This small split could be formed during processing of the sample.

DISTRIBUTION: A single specimen in the middle of the section was recovered.

FIGURED SPECIMEN: Pl. fig. 15, slide no. DUN 213-1, Co-ord. 59.3/122.8.

SCHIZOSPORIS sp. B

Plate 8, Figs. 16, 17

DESCRIPTION: Spore biconvex, may or may not be equatorially split, exine relatively thick, with faint granulation or punctation.

SIZE: Length - 80-82 microns.

Breadth - 44-54 microns.

DISTRIBUTION: Common in the middle part of the type section.

FIGURED SPECIMEN: Pl. 8, figs. 16, 17, slide no. DUN 191-2, Co-ord. 43.1/121.8, 34.9/123.9.

FAMILY CAYTONIACEAE

Genus VITREISPORITES Leschik, 1955, emend. Jansonius, 1962

- 1955 Vitreisporites signatus Leschik, Schweiz. Palaeont. Abhandl., p. 53, pl. 8, fig. 10 (type species).
1962 Vitreisporites Leschik, emend. Jansonius, Palaeontographica, Band 110, Abt. B, p. 55.

DIAGNOSIS: Bisaccate, central body oval, longer than broader, bladders finely reticulate and proximally attached at equator, distally reaching up to distal pole, leaving a small germinal area, body less than 20 microns.

VITREISPORITES PALLIDUS (Reissinger) Nilsson, 1958

Plate 9, Fig. 1

- 1938 Pityosporites pallidus Reissinger, Palaeontographica B. 84, Abt. B, p. 14.
1950 Pityopollenites pallidus Reissinger, Palaeontographica, Band 90, Abt. B, p. 109, pl. 15, figs. 1-5.
1958 Caytonipollenites pallidus (Reissinger) Couper, Palaeontographica, Band 103, Abt. B, p. 150, pl. 26, figs. 7, 8.
1958 Vitreisporites pallidus (Reissinger) Nilsson, Publ. Inst. Mineral., Paleont. Quat. Geol. Univ. Lund. No. 53, p. 77-78.
1964 Vitreisporites pallidus (Reissinger) Nilsson - Singh Res., Coun. Alberta Bull. 15, p. 102, pl. 14, fig. 1.

DESCRIPTION: See Singh (1964, p. 103).

SIZE: Total Breadth = 20 microns.

Breadth of central body = 16 microns.

Length of bladders = 18 microns.

Breadth of bladders = 8-6 microns.

DISTRIBUTION: Jurassic and Cretaceous. Common in Dunvegan Formation.

FIGURED SPECIMEN: Pl. 9, fig. 1, slide no. DUN 126-1, Co-ord. 50.4/126.1.

Order CYCADALES or BENNETTITALES

Genus CYCADOPITES Wodehouse, 1933 ex Wilson and Webster, 1946

1933 Cycadopites Wodehouse, Bull. Torrey Botan. Club, Vol. 60, p. 483, figs. 5, 6.

1946 Cycadopites follicularis Wilson and Webster, Am. J. Botany, Vol. 33, p. 274, pl. 1, fig. 7 (type species designated by Potonie 1958).

DIAGNOSIS: Monosulcate pollen grains, spindle shaped, sulcus extending to total length of grain and broadening at the longitudinal ends; sulcus usually closed in the middle by furrow edges overlapping in shrinkage.

CYCADOPITES FRAGILIS Singh, 1964

Plate 9, Fig. 2

1962 Monosulcites minimus Cookson, Palaeontographica, Band III, Abt. B, p. 77, pl. 13, figs. 206-208.

1964 Cycadopites fragilis Singh, 1964 Res. Coun. Alberta, Bull. 15, p. 103, pl. 14, fig. 2.

DISTRIBUTION: Jurassic and Cretaceous. Common in Dunvegan type section.

FIGURED SPECIMEN: Pl. 9, fig. 2, slide no. DUN 126-1, Co-ord. 68/114.

CYCADOPITES CARPENTIERI (Delcourt and Sprumont) Singh 1964

Plate 9, Fig. 3

- 1955 Monosulcites carpentieri Delcourt and Sprumont, Mem. Soc. Geol. Belgique, N.S., Vol. 4, p. 54, fig. 14.
- 1964 Cycadopites carpentieri (Delcourt and Sprumont) Singh, Res. Coun. Alberta, Bull. 15, p. 104, pl. 14, fig. 3.

DESCRIPTION: See Singh (1964, p. 104).

SIZE: Length - 46 microns.

Breadth - 28 microns.

DISTRIBUTION: Jurassic to Upper Cretaceous, common in the upper part of 'Dunvegan' type section.

FIGURED SPECIMEN: Pl. 9, fig. 3, slide no. DUN 213-1, Co-ord. 50.6/124.1.

CYCADOPITES sp. A

Plate 9, Figs. 4, 5

DESCRIPTION: Monosulcate, sulcus running entire length of grain, furrow edges may meet in the middle, always broader at the longitudinal ends, bordered by lips, exine thick, punctate in some specimen and granulose in others.

SIZE: Length - 56-69 microns.

Width - 43 microns.

REMARKS: This species differs from Cycadopites formosus Singh 1964 by the presence of punctate or granulose exine, and from Cycadopites scabratus Stanley, 1965, by size and ornamentation.

DISTRIBUTION: Common in the upper part of 'Dunvegan' type section.

FIGURED SPECIMEN: Pl. 9, figs. 4, 5, slide no. DUN 162-3,
Co-ord. 54.3/119, 35.7/119.1.

CYCADOPITES sp. B

Plate 9, Figs. 6, 7

DESCRIPTION: Monosulcate, sulcus running entire length of grain, broader at one or both longitudinal ends, exine moderately thick and scabrous.

SIZE: Length - 78 microns.

Breadth - 20-35 microns.

DISTRIBUTION: Common in the upper part of the 'Dunvegan' type section.

FIGURED SPECIMEN: Pl. 9, figs. 6, 7, slide no. DUN 191-1,
Co-ord. 46.9/115.5.

ORDER CONIFERALES

FAMILY TAXODIACEAE

Genus TAXODIACEAPOLLENITES (Potonie, 1931) Kremp, 1949

- 1931 Pollenites hiatus Potonie, Preussischen Geologischen. Landesanstalt, Jahrbuch, Vol. 52, p. 5, fig. 27.
- 1949 Taxodiaceapollenites (Pollenites) hiatus (Potonie 1931) Kremp, Palaeontographica, Abt. B., Vol. 90, p. 59, pl. 7, fig. 6 (type species).
- 1965 Thuja? hiatus (Potonie) Stanley, Bull. Am. Paleont., Vol. 49, No. 222, p. 273, pl. 38, figs. 1-3.

DIAGNOSIS: Pollen grain spherical to subspherical, splitting into two halves, while remaining attached at one end; exine punctate and thin.

TAXODIACEAPOLLENITES HIATUS Kremp 1949

Plate 9, Figs. 8, 9

(Synonymy as for genus)

DESCRIPTION: Pollen subspherical, splitting in two halves but attached at one end, exine punctate and thin.

SIZE: 22-32 microns.

DISTRIBUTION: Upper Cretaceous and Paleocene. Common in Dunvegan type section.

FIGURED SPECIMEN: Pl. 9, figs. 8, 9, slide no. DUN 191-1, Co-ord. 59.1/111, 27.3/112.7.

FAMILY CUPRESSACEAE

Genus INAPERTUROPOLLENITES Pflug ex Thomson and Pflug emend. Potonie 1958

1953 Inaperturopollenites dubius (Potonie and Venitz) Thomson and Pflug, Palaeontographica, Band 94, Abt. B, p. 65, pl. 4, figs. 8, 9, pl. 5, figs. 1-13 (type species).

DIAGNOSIS: Equatorial contour rounded, exine thin, infra-punctate, secondary folds present, grains with aperture.

INAPERTUROPOLLENITES DUBIUS (Potonie and Venitz, 1934
Thomson and Pflug 1953

Plate 9, Fig. 10

(Synonymy as for genus)

DESCRIPTION: Inaperturate, equatorial contour rounded, secondary folds in various planes present, exine thin infra punctate or granulate.

SIZE: 24 microns.

DISTRIBUTION: Mesozoic and Tertiary, common in 'Dunvegan' type section.

FIGURED SPECIMEN: Pl. 9, fig. 10, slide no. DUN 126-4,
Co-ord. 58.5/119.3.

FAMILY ARAUCARIACEAE

Genus ARAUCARIACITES Cookson ex Couper 1953

- 1947 Granulonapites (Araucariacites) australis Cookson, B.A.N.Z. Antarctic Res. Expedition 1929-1931, Repts. Series A, Vol. 2, pt. 8, p. 130, pl. 13, figs. 1-4.
- 1953 Araucariacites australis Cookson-Couper, New Zealand Geol. Surv. Palaeont. Bull. 22, p. 39, (type species designated).

DIAGNOSIS: Pollen grain large, flattened, folded, finely granular.

ARAUCARIACITES AUSTRALIS Cookson 1947

Plate 9, Fig. 11

(Synonymy as for genus)

DESCRIPTION: Pollen grain large, flattened, granulose.

SIZE: 43 microns.

DISTRIBUTION: Tertiary, common in the Dunvegan type section.

FIGURED SPECIMEN: Pl. 9, fig. 11, slide no. DUN 126-4,
Co-ord. 65.3/122.5, 66.6/124.5.

FAMILY PINACEAE

Genus ALISPORITES Daugherty, 1941, restr. Potonie and Kremp 1956

- 1941 Alisporites opii Daugherty, Carnegie Inst. Washington Publ. 526, p. 98, pl. 34, fig. 2 (type species).
- 1956 Alisporites opii Daugherty, restr. Potonie and Kremp, Palaeontographica, Band 99, Abt. B, p. 176-177, fig. 82.
- 1959 Alisporites Daugherty, emend. Rouse, Micropaleont., Vol. 5, p. 314, pl. 1.

DIAGNOSIS: Bisaccate pollen, equatorial outline circular; distal furrow parallel-sided, not covered by the bladders, central body ill defined; bladders reticulate thin and slightly pendant.

ALISPORITES ROTUNDUS Rouse, 1959

Plate 9, Fig. 12

- 1959 Alisporites rotundus Rouse, Micropaleont., Vol. 5, p. 316, pl. 1, figs. 15-16.
- 1964 Alisporites rotundus Rouse - Singh, Res. Coun. Alberta, Bull. 15, p. 110, pl. 14, figs. 13, 14, pl. 1, figs. 1, 2.

DESCRIPTION: See Singh (1964, p. 110).

SIZE: Total breadth - 86 microns.

Length of central body - 50 microns.

Length of bladders - 60 microns.

DISTRIBUTION: Reported from Upper Jurassic by Rouse (1959). Also present in Lower Cretaceous (Singh 1964). Rare in 'Dunvegan' type area.

FIGURED SPECIMEN: Pl. 9, fig. 12, slide no. DUN 126-4, Co-ord. 65.7/121.7.

ALISPORITES sp. cf. A. MICROSACCUS (Couper) Pocock, 1962

Plate 9, Fig. 13

- 1958 Pteruchipollenites microsaccus Couper, Palaeontographica, Band 103, Abt. B, p. 151, pl. 26, figs. 13, 14.
- 1962 Alisporites cf. A. microsaccus (Couper) Pocock, Palaeontographica, Band III, Abt. B, p. 61, pl. 9, figs. 138, 139.
- 1964 Alisporites sp. cf. A. microsaccus (Couper) Pocock - Singh, Res. Coun. Alberta, Bull. 15, p. 102, pl. 14, fig. .

DESCRIPTION: Bisaccate, central body subcircular; bladders longer than broad, giving grain more or less circular outline in equatorial view; body finely granular; bladders finely reticulate, slightly pendant distally, enveloping a large part of the distal face, leaving a narrow inverted V shaped space in centre.

SIZE: Total breadth - 63 microns.

Breadth of central body - 43 microns.

Length of bladders - 32 microns.

Breadth of bladders - 29 microns.

DISTRIBUTION: Upper Jurassic and Lower Cretaceous. Present in Vanguard Formation (Pocock, 1962) and rare in Lower Mannville Groupe (Singh, 1964). Common in 'Dunvegan' type section.

FIGURED SPECIMEN: Pl. 9, fig. 13, slide no. DUN 248-6, Coord. 46.5/128.

Genus CEDRIPITES Woodhouse, 1933

- 1933 Cedripites eocenicus Woodhouse, Bull. Torrey Botan. Club, Vol. 60, p. 489-490, fig. 13 (type species).

DIAGNOSIS: Bisaccate pollen, proximal cap thick, somewhat

curved marginal crest; bladder fused with proximal cap giving the impression of continuity along the proximal pole, bladders concave on the distal side, somewhat covering the central body.

AFFINITY: The living genus Cedrus of family Pinaceae has morphological characters similar to the organ genus Cedripites.

CEDRIPITES CANADENSIS Pocock, 1962

Plate 9, Fig. 14

1962 Cedripites canadensis Pocock, Palaeontographica, Band III, Abt. B, p. 63, pl. 10, figs. 149, 150.

1964 Cedripites canadensis Pocock, Singh, Res. Coun. Alberta, Bull. 15, p. 112, pl. 15, fig. 6.

DESCRIPTION: See Singh (1964, p. 112).

SIZE: Total breadth - 55 microns.

Breadth of central body - 51 microns.

Length of central body - 51 microns.

Breadth of bladders - 10-12 microns.

Length of bladders - 41 microns.

DISTRIBUTION: Barremian to Cenomanian. Common.

FIGURED SPECIMEN: Pl. 9, fig. 14, slide no. DUN 126-3,

Co-ord. 46.8/124.6.

CEDRIPITES CRETACEUS Pocock, 1962

Plate 9, Fig. 15

1962 Cedripites cretaceus Pocock, Palaeontographica, Band III, Abt. B, p. 63, pls. 9, 10, figs. 145-148.

1964 Cedripites cretaceus Pocock - Singh, Res. Coun. Alberta, Bull. 15, p. 111, pl. 15, figs. 3, 5.

DESCRIPTION: See Singh (1964, p. 111).

SIZE: Total breadth - 66 microns.

Breadth of central body - 50 microns.

Length of central body - 30 microns.

Breadth of bladders - 20 microns.

Length of bladders - 34 microns.

DISTRIBUTION: Middle Albian to Cenomanian. Few specimens recovered.

FIGURED SPECIMEN: Pl. 9, fig. 15, slide no. DUN 126-4,
Co-ord. 67.5/118.4.

Genus PHYLLOCLADIDITES Cookson, 1947 ex Couper, 1953

- 1947 Disaccites (Phyllocladidites) mawsonii Cookson, B.A.N.Z. Antarctic, Res. Expedition, Rept. A.2, p. 133, pl. 14, figs. 22-28.
- 1953 Dacrydiumites mawsonii (Cookson) Cookson, Australian J. Botany, Vol. I, p. 66, Bull. 22, p. 38, pl. 9, fig. 135 (type species).
- 1960 Dacrydiumites mawsonii Cookson - Couper, New Zealand Geol. Surv. Paleont. Bull. 32, p. 43, pl. 3, figs. 7, 8.

DIAGNOSIS: Bisaccate, equatorial outline circular, oval or polygonal; proximal cap distinct and extends onto the distal surface, bladders very small with indistinct reticulum, strongly distally pendant; bladders do not extend beyond the equator of central body, a broad clearly defined distal furrow present between the two bladders; bladders thick and rigid; exine granular and thickened at the proximal root of each bladder close to the equatorial margin.

AFFINITY: Probable affinities with family Podocarpaceae.

PHYLLOCLADIDITES sp.

Plate 9, Fig. 16

DESCRIPTION: Bisaccate, equatorial outline rounded polygonal; exine coarse granular; bladders small in comparison to central body, thick, granular, half-moon shaped, attached on distal side leaving a clearly defined furrow in between the bladders.

SIZE: Total breadth - 25 microns.

Breadth of central body - 25 microns.

Length of central body - 31 microns.

Breadth of bladders - 10 microns.

Length of bladders - 20 microns.

DISTRIBUTION: A single specimen was recovered in the upper part of the type area.

FIGURED SPECIMEN: Pl. 9, fig. 16, slide no. DUN 213-3,
Co-ord. 47.7/122.1.

Genus PITYOSPORITES Seward, 1914, emend. Manum, 1960

1914 Pityosporites antarcticus Seward, British Antarctic (Terra Nova) Expedition 1910, Nat. Hist. Rept., Geol. I, p. 23, pl. 8, fig. 45 (type species).

1960 Pityosporites antarcticus Seward, emend. Manum, Nytt Mag. Bot., vol. 8, p. 14, pl. I, figs. 1-4.

DIAGNOSIS: Bisaccate pollen grains; bladders distally pendant, narrowing somewhat towards their roots and diverging, proximally roots reaching equator of the body or slightly farther, bladders reticulate, body wall smooth or sculptured.

AFFINITY: Pityosporites according to Seward (1914) shows a

close resemblance to modern pollen belonging to the family Pinaceae.

PITYOSPORITES sp. A

Plate 9, Fig. 17

DESCRIPTION: Bisaccate, bladders small in comparison to central body; body wall granular with folds; bladders broad and reticulate.

SIZE: Total breadth - 76 microns.

Breadth of central body - 50 microns.

Length of central body - 46 microns.

Breadth of bladders - 20 microns.

Length of bladders - 36 microns.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 9, fig. 17, slide no. DUN 248-6,

Co-ord. 27.3/127.1.

FAMILY PODOCARPACEAE

Genus *PODOCARPIDITES* Cookson, 1947 ex Couper, 1953

- 1947 *Podocarpidites ellipticus* Cookson, B.A.N.Z. Antarctica Res. Exped. Rept. A2, p. 131, pl. 13, figs. 5-7 (type species).
- 1953 *Podocarpidites* cf. *P. ellipticus* Cookson - Couper, New Zealand Geol. Surv. Palaeont. Bull. 22, p. 35.
- 1964 *Podocarpidites* sp. cf. *P. ellipticus* Cookson - Singh, Res. Coun. Alberta, Bull. 15, p. 115, pl. 15, fig. 11.

DIAGNOSIS: Bisaccate pollen grains; equatorial outline of central body oval to polygonal; bladders large, pendant distally, length of bladders always greater than length of central body.

AFFINITY: The pollen under the form-genus Podocarpidites are similar to pollen belonging to modern family Podocarpaceae.

PODOCARPIDITES sp. cf. P. ELLIPTICUS Cookson, 1947

Plate 9, Figs. 18, 19

(Synonymy as for genus)

DESCRIPTION: Bisaccate, central body circular in equatorial view; marginal crest indistinct; bladders larger, pendant distally; central body granulose and bladders reticulate.

SIZE: Total breadth = 71 microns.

Breadth of central body = 39 microns.

Length of central body = 34 microns.

Breadth of bladders = 43 microns.

DISTRIBUTION: Jurassic-Tertiary. Common at the 'Dunvegan' type section.

FIGURED SPECIMEN: Pl. 9, figs. 18, 19, slide no. DUN 126-4, Co-ord. 44/116.9, DUN 191-1, Co-ord. 46.5/120.1.

PODOCARPIDITES MULTESIMUS (Bolkhovitina) Pocock, 1962

Plate 9, Fig. 20

1962 Podocarpidites multesimus (Bolkhovitina) Pocock, Palaeontographica, Band III, Abt. B, p. 67, pls. 10, 11, figs. 161-163.

1964 Podocarpidites multesimus (Bolkhovitina) Pocock - Singh, Res. Coun. Alberta, Bull. 15, p. 116, pl. 15, fig. 12.

DESCRIPTION: See Singh (1964, p. 116).

SIZE: Total breadth = 76 microns.

Length of central body = 40 microns.

Breadth of central body = 40 microns.

Length of bladders = 48 microns.

Breadth of bladders = 30 microns.

DISTRIBUTION: Jurassic and Cretaceous. A single specimen was recovered.

FIGURED SPECIMEN: Pl. 9, fig. 20, slide no. DUN 126-3, Co-ord. 34.8/122.2.

PODOCARPIDITES sp. A

Plate 9, Fig. 21

DESCRIPTION: Bisaccate, central body oval; marginal crest distinct, thick; bladders large, thick walled with indistinct reticulation; central body and marginal crust granulose.

SIZE: Total breadth = 50 microns.

Breadth of central body = 30 microns.

Length of central body = 32 microns.

Breadth of bladders = 13 microns.

Length of bladders = 37 microns.

DISTRIBUTION: Rare in Upper part of the type section.

FIGURED SPECIMEN: Pl. 9, fig. 21, slide no. DUN 191-1, Co-ord. 42/115.7.

Genus TSUGAEPOLLENITES Potonie and Venitz, 1934

1934 Tsugaepollenites igniculus (Potonie) Potonie and Venitz, Arb. Inst. Palaobot. Petrogr. Brennsteine, Vol. 5, p. 17, pl. 1, fig. 8 (type species).

DIAGNOSIS: Pollen grains, equatorial outline circular with a

narrow equatorial velum, frill like, radially folded; margin undulating, exine rugulate.

TSUGAEPOLLENITES sp.

Plate 10, Figs. 1, 2

DESCRIPTION: Pollen grain, equatorial outline circular, equatorial velum somewhat indistinct, folded, margin undulating; exine rugulate.

SIZE: 34-38 microns.

DISTRIBUTION: Few specimens recovered from the upper part of the type section.

FIGURED SPECIMEN: Pl. 10, figs. 1, 2, slide no. DUN 126-3, Co-ord. 67/114.8, DUN 248-2, Co-ord. 63.8/129.3.

FAMILY EPHEDRACEAE

Genus EQUISETOSPORITES Daugherty, 1941, emend. Singh 1964

- 1941 Equisetosporites chinleana Daugherty, Carnegie Inst. Washington, Publ. 526, p. 63, pl. 24, fig. 4 (type species).
- 1960 Ephedra chinleana (Daugherty) Scott, Micropaleont., Vol. 6, p. 271, pl. 1, figs. 1-8, 10-12, 14-18, text figs. 1, 2.
- 1961 Striainaperturites Pierce, Minnesota Geol. Surv. Bull. 42, p. 45, pl. 3, fig. 80.
- 1964 Equisetosporites Daugherty, 1941, emend. Singh, Res. Coun. Alberta Bull. 15, p. 129.

DIAGNOSIS: Acolpate pollen grains, ellipsoid, narrower at one end; exine two layered, endexine smooth overlain by unbranched ektexinous ridges from 2-12 microns wide, 8 to 25 in number; twisting of

ridges due to fossilization, ridges coalescing at the longitudinal ends.

COMPARISON: The form-genus Equisetosporites (of family Ephedraceae) can be distinguished from the genus Schizaeoisporites (of family Schizaeaceae) by its wide, low, gently rounded, unbranched ridges. The genus Schizaeoisporites generally has narrower, high and branched ridges.

EQUISETOSPORITES CONCINNUS Singh 1964

Plate 10, Fig. 3

1964 Equisetosporites concinnus Singh, Res. Coun. Alberta, Bull. 15, p. 132, pl. 17, figs. 10-15.

DESCRIPTION: See Singh (1964, p. 132).

SIZE: Length - 82 microns.

Breadth - 34 microns.

DISTRIBUTION: Barremian to Cenomanian. Rare in 'Dunvegan' type section.

FIGURED SPECIMEN: Pl. 10, fig. 3, slide no. DUN 126-2, Co-ord. 62.8/120.

EQUISETOSPORITES sp. cf. E. OVATUS (Pierce) Singh 1964

Plate 10, Fig. 4

1961 Straiaiaperturites ovatus Pierce, Minnesota Geol. Surv. Bull. 42, p. 45, pl. 3, fig. 80.

1964 Equisetosporites sp. cf. E. ovatus Singh, Res. Coun. Alberta Bull. 15, p. 133, pl. 17, fig. 16.

DESCRIPTION: See Singh (1964, p. 133).

SIZE: Length - 39 microns.

Breadth - 12 microns.

DISTRIBUTION: Aptian to Cenomanian. A single specimen was reported from Aptian sediments. Pierce (1961) recorded in Cenomanian of Minnesota. Rare.

REMARKS: The specimens recovered are smaller in dimension from the specimen described by Pierce (1961) and Singh (1964).

FIGURED SPECIMEN: Pl. 10, fig. 4, slide no. DUN 126-1,
Co-ord. 51.8/125.8.

Pollen Type A

Plate 10, Fig. 5

DESCRIPTION: Bisaccate pollen, body spindle shaped with two wings attached on the distal side leaving in between a small parallel sided space or furrow; bladders slightly exceed the breadth of central body.

SIZE: Total breadth - 50 microns.

Length of central body - 84 microns.

Breadth of bladder - 24 microns.

Length of bladder - 25 microns.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 10, fig. 5, slide no. DUN 126-4,
Co-ord. 50/125.

ANGIOSPERMAE

FAMILY LILIACEAE

Genus LILIACIDITES Couper 1953

1953 Liliacidites kaitangataensis Couper, New Zealand Geol. Surv. Paleont. Bull. 22, p. 56, pl. 7, fig. 97.

DIAGNOSIS: Monosulcate occasionally tricolpate; sulcus long, broad; exine reticulate, clavate or baculate.

LILIACIDITES VARIEGATUS Couper 1953

Plate 10, Figs. 6, 7

1953 Liliacidites variegatus Couper, New Zealand Geol. Surv. Paleont., Bull. 22, p. 56, pl. 7, figs. 98, 99.

DESCRIPTION: Pollen grains, monocolpate, colpi long, oval meridinal contour; exine clavate, reticulate.

SIZE: 20 x 14 microns.

DISTRIBUTION: Couper (1953) described from the Upper Cretaceous to Lower Oligocene in New Zealand. Groot et. al. (1961) reported from Tuscaloosa and Magothy Formation (Turonian to Lower Senonian) of the Atlantic coastal plains. Hedlund (1966) reported from Woodbine Formation (Oklahoma). Pierce (1961) reported similar form, Retimonocolpites fragilis from the Cenomanian of Minnesota. Common in the Upper part of the section.

FIGURED SPECIMEN: Pl. 10, figs. 6, 7, slide no. DUN 191-1, Co-ord. 38.7/121.9.

LILIACIDITES sp.

Plate 10, Fig. 8

DESCRIPTION: Pollen grains, monosulcate, exine thickened around the colpi, exine scabrate.

SIZE: 12 x 10 microns.

DISTRIBUTION: Abundant in upper part of the type section.

FIGURED SPECIMEN: Pl. 10, fig. 8, slide no. DUN 191-1, Co-ord. 41/118.3.

FAMILY BETULACEAE

Genus ALNIPOLLENITES Potonie, 1931

1931 Alnipollenites Potonie.

1934 Alnipollenites verus (Potonie) Potonie, Med. Klinik, Wochenschr. f. prakt. Ärzte, N. 37, S. 58, Taf. 2, fig. 17.

1937 Alnuspollenites Raatz.

1953 Polyvestibulopollenites Pflug, Palaeontographica, Abt. B, Bd. 95.

DIAGNOSIS: Pores 3 to 7, situated in equatorial plane, when pores four or more polar view is square or polygonal; exine smooth or scabrate, thickened in the region surrounding pores.

ALNIPOLLENITES sp.

Plate 10, Fig. 9

DESCRIPTION: Pollen grains, ?tetraporate, arci present, equatorial outline square shaped; exine laevigate.

SIZE: 40 x 40 microns.

REMARKS: A single specimen recorded in the middle part of the type section looks similar to Alnus quadrapollenites Rouse, 1962, excepting the size range, which in latter varies from 25-27 microns. The present specimen is provisionally put under Alnipollenites because of poorly visible pores.

FIGURED SPECIMEN: Pl. 10, fig. 9, slide no. DUN 191-2,
Co-ord. 55.9/125.1.

FAMILY NYMPHAEACEAE

Pollen, Genus cf. NUPHAR

Plate 10, Fig. 10

REMARKS: Monosulcate grains with thick exine; spines all over the exine. Such characters are present in living genus Nuphar. A new genus may be created for such type of pollen. According to Heintz (1927) the genus Nuphar is among the most primitive dicotyledons.

DESCRIPTION: Pollen grains, monosulcate, exine thick, short spines distributed over exine.

SIZE: 34 x 20 microns.

AFFINITY: Affinity with living genus Nuphar.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 10, fig. 10, slide no. DUN 126-1,
Co-ord. 55.5/120.

ANGIOSPERMAE - INCERTAE SEDIS

Genus *TRICOLPITES* Cookson ex Couper emend. Belsky,
Boltenhagen and Potonie 1965

- 1947 *Tricolpites reticulatus* Cookson, Boltenhagen and Potonie 1965,
B.A.N.Z. Antarctic Research Expedition 1929-1931. Rept. Series A,
Vol. 2, pt. 8, p. 134, pl. 15, fig. 45 (type species).
- 1953 *Tricolpites reticulatus* Cookson ex Couper, New Zealand Geol. Surv.
Paleont. Bull. 22, p. 61.
- 1965 *Tricolpites* Cookson ex Couper emend. Belsky, Boltenhagen and
Potonie, Palaont. Z. 39, p. 75.

DIAGNOSIS: Oblate to spheroidal; ornamentation fine reticulate;
no thick exine at the margin of the colpi.

TRICOLPITES RETICULATUS Cookson, 1947

Plate 10, Figs. 11, 12

- 1947 *Tricolpites reticulatus* Cookson, B.A.N.Z. Antarctic Research
Expedition 1929-1931, Rept. Series A, vol. 2, pt. 8, p. 134, pl. 15.

DESCRIPTION: Pollen grains; tricolpate; colpi long but narrow,
equatorial outline circular; exine reticulate.

SIZE: 20 x 20 microns.

DISTRIBUTION: Reported by Hedlund (1966) from Woodbine
Formation, Clarke (1963) from Upper Cretaceous Vermego Formation (Colorado).
Pierce (1961) described similar form, *Retricolpites minutus* from the
Cenomanian of Minnesota. Common in the Upper part of the type section.

FIGURED SPECIMEN: Pl. 10, figs. 11, 12, slide no. DUN 191-2,
Co-ord. 52.3/123.

Genus TRICOLPOPOLLENITES Pflug and Thomson 1953

- 1953 Tricolpopollenites parmularius (Potonie) Pflug and Thomson, Palaeontographica Band 94, Abt. B, p. 95, pl. 11, fig. 158 (type species).

TRICOLPOPOLLENITES DEBILIS Groot, Penny and Groot, 1961

Plate 10, Fig. 13

- 1961 Tricolpopollenites debilis Groot, Penny and Groot, Palaeontographica Band 108, Abt. B, p. 132, pl. 26, fig. 5.

DESCRIPTION: Pollen grains; tricolpate; colpi long, wide open in polar view; prolate; exine scabrate.

SIZE: 12 x 8 microns.

DISTRIBUTION: Reported by Groot et. al. (1961) from Tuscaloosa Formation. Common.

FIGURED SPECIMEN: Pl. 10, fig. 13, slide no. 191/4, Co-ord. 60.7/123.2.

TRICOLPOPOLLENITES sp. A

Plate 10, Fig. 14

DESCRIPTION: Pollen grains tricolpate; colpi 6 microns long; half moon shaped; exine finely reticulate to scabrate.

SIZE: 14 x 14 microns.

DISTRIBUTION: Common in the Upper part of the type section.

FIGURED SPECIMEN: Pl. 10, fig. 14, slide no. DUN 191-1, Co-ord. 62.3/115.1.

TRICOLPOPOLLENITES sp. B

Plate 10, Fig. 15

DESCRIPTION: Pollen grains tricolpate; colpi U shaped, extending to polar region, polar outline rounded triangular; exine finely ?reticulate.

SIZE: 14 x 14 microns.

DISTRIBUTION: Common in the Upper part of the type section.

FIGURED SPECIMEN: Pl. 10, fig. 15, slide no. DUN 191-1,
Co-ord. 49.7/120.2.

TRICOLPOPOLLENITES sp. C

Plate 10, Figs. 16, 17

DESCRIPTION: Pollen grains; tricolpate; colpi broad wedge shaped, 6 microns wide; exine thin, ?baculate.

SIZE: 18 x 18 microns.

DISTRIBUTION: Common in the Upper part of the type section.

FIGURED SPECIMEN: Pl. 10, figs. 16, 17, slide no. DUN 213-1,
Co-ord. 34/48.6.

Genus TRICOLPOROPOLLENITES Pflug and Thomson 1953

1953 Tricolporopollenites dolium (Potonie) Pflug and Thomson, *Palaeontographica* Abt. B, Band 94, p. 98, pl. 12, figs. 114-117 (type species).

TRICOLPOROPOLLENITES ALIQUANTULUS Hedlund, 1966

Plate 10, Fig. 18.

1966 Tricolporopollenites aliquantulus Hedlund, OKL. Geol. Surv. Bull. 112, p. 30, pl. 9, figs. 4a, b.

DESCRIPTION: Pollen grains tricolporate; colpi long extending almost entire length of the grain, polar outline rounded, triangular, exine smooth or granular.

SIZE: 12 x 11 microns.

DISTRIBUTION: Hedlund (1966) described from Woodbine Formation (Cenomanian). Abundant in the upper part of the type section.

AFFINITY: Angiospermous pollen grains.

FIGURED SPECIMEN: Pl. 10, fig. 18, slide no. DUN 191-4, Co-ord. 48.6/115.8.

TRICOLPOROPOLLENITES sp. A

Plate 10, Fig. 19

DESCRIPTION: Pollen grains, tricolporate, colpi extending almost entire length of the grain, polar outline rounded triangular, pores present, exine punctate-scabrate.

SIZE: 14 x 12 microns.

REMARKS: This species differs from Tricolporopollenites orbiculatus Groot et. al. (1961) by the presence of punctate-scabrate exine.

FIGURED SPECIMEN: Pl. 10, fig. 15, slide no. DUN 191-1, Co-ord. 36.3/128.

TRICOLPOROPOLLENITES sp. B

Plate 11, Fig. 1

DESCRIPTION: Pollen grains, tricolporate; colpi very narrow reaching almost entire length of pollen grain, pores somewhat indistinct,

polar outline subcircular, exine thickened around pores, reticulate to scabrate.

SIZE: 14 microns.

REMARKS: This species differs from Tricolporopollenites sp. A by the presence of a circular polar outline and lack of a distinct notch formed by colpi, when seen in polar view.

DISTRIBUTION: Common.

FIGURED SPECIMEN: Pl. 11, fig. 1, slide no. DUN 191-1,
Co-ord. 54/111.2.

Genus TRIPOROPOLLENITES Pflug and Thomson 1959

1959 Triporopollenites coryloides Pflug and Thomson Palaeontographica,
Band 94, p. 82, pl. 9, fig. 20 (type species).

TRIPOROPOLLENITES sp. A

Plate 11, Figs. 2, 3

DESCRIPTION: Pollen grain, triporate, isopolar, pores about 1 micron, exine moderately thick and punctate.

SIZE: 14 x 14 microns.

DISTRIBUTION: Common.

FIGURED SPECIMEN: Pl. 11, figs. 2, 3, slide no. DUN 99-1,
Co-ord. 30.5/114.5.

TRIPOROPOLLENITES sp. B

Plate 11, Figs. 4, 5

DESCRIPTION: Pollen grains, triporate, pores small, equatorial

outline oval; exine faintly scabrate, thick.

SIZE: 14 x 10 microns.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 11, figs. 4, 5, slide no. DUN 191-1,
Co-ord. 38.4/110.9.

Genus LATIPOLLIS Krutzsch, 1959

1959 Latipollis subtilis Krutch, Palaeontographica, Vol. 105, Abt. B,
p. 129, pl. 31, figs. 1-12 (type species).

DIAGNOSIS: Pollen grain, triplane, triporate, pores with
annulus, exine psilate to scabrate.

LATIPOLLIS NORMIS Krutzsch, 1959

Plate 11, Figs. 6, 7

1959 Latipollis normis Krutzsch, Palaeontographica Vol. 105, Abt. B,
p. 129, pl. 31, figs. 20-26.

DESCRIPTION: Pollen grains, triplane seen in equatorial view
only pores with ? annulus, exine psilate to indistinctly scabrate.

SIZE: 11 x 10 microns.

DISTRIBUTION: Reported by Krutzsch (1959) from Upper Cretaceous
of Germany. These specimens are very small, however, comparison with the
figured specimen of Krutzsch (1959) and Groot et. al. (1961, pl. 26, figs.
47, 48) indicates close resemblance with their specimen. Common in the
middle part of the type section.

FIGURED SPECIMEN: Pl. 11, figs. 6, 7, slide no. DUN
Co-ord.

LATIPOLLIS sp.

Plate 11, Figs. 8, 9, 10

DESCRIPTION: Tri-plane pollen, Y shaped contour, extremity of each plane having an oval pore with a slightly developed annulus; exine psilate to scabrate.

SIZE: 29 microns.

REMARKS: This species strikingly resembles with the gross morphology of Latispolli vulgaris Groot and Groot, 1962. Reported from Portugal. However L. vulgaris has a constriction on either side of the pores, which was found absent in Dunvegan specimens.

DISTRIBUTION: Common.

FIGURED SPECIMEN: Pl. 11, figs. 8, 9, 10, slide no. DUN 191-1, Co-ord. 45.6/125.8.

Genus STEPHANOCOLPITES (Van der Hammen, 1954, 1956) Potonie, 1956

1954 Stephanocolpites costatus Van der Hammen, Bogota, Boletín Geol. Vol. 2, p. 97, pl. 7 (type species).

1960 Stephanocolpites costatus (Van der Hammen) Potonie, Beih. Geol. Jb. 39, p. 96, pl. 6, fig. 105.

DIAGNOSIS: Pollen grains, polycolpate, colpi not reaching the polar ends, exine ornamented.

STEPHANOCOLPITES sp.

Plate 11, Figs. 11, 12

DESCRIPTION: Pollen grains polycolpate; prolate, colpi broad, long but not reaching the polar ends of the grain, ellipsoidal, exine thin,

tectate, ekstexine baculate.

SIZE: 22 x 16 microns.

REMARKS: This species differs from Stephanocolpites tectorius Hedlund 1966, by the presence of baculate ekstexine, and smaller size.

DISTRIBUTION: Rare.

FIGURED SPECIMEN: Pl. 11, figs. 11, 12, slide no. DUN 213-3, Co-ord. 22.3/122.8.

MEGASPORES

Genus TRILETES Reinsch, 1881, emend. Schopf, 1938

1938 Triletes reinschi (Ibrahim) Schopf. Illinois State Geol. Surv., Rept. Invest. 50, p. 0-73 (type species).

DIAGNOSIS: Megaspores, radially symmetrical; equatorial outline circular, proximal surface with triradiate suture, distal surface may be smooth, granulate or rugulate equatorial diameter 150 microns or more.

TRILETES sp. A

Plate 12, Figs. 1, 2

DESCRIPTION: Megaspore more or less circular, spore wall sunken, proximal side marked by a distinct triradiate mark separating three equal contact faces, spore cracked along the triradiate mark, spore wall cracked with irregular ridges, thick.

SIZE: Equatorial diameter = 400 microns or more.

REMARKS: This species is comparable to Triletes sp. B of Singh (1964, p. 150, pl. 21, fig. 3).

DISTRIBUTION: Recovered from middle part of the type section.

FIGURED SPECIMEN: Pl. 12, figs. 1, 2, slide no. Mega DUN 126-2,
Co-ord. 55/114.9.

TRILETES sp. B

Plate 12, Fig. 3

DESCRIPTION: Megaspore, trilete, laesurae thick, slightly irregular, extends to full length of spore, equatorial outline circular surface finely granulate with numerous uniformly distributed hair like processes, hollow and open at the apex, exine moderately thick.

SIZE RANGE: Equatorial diameter - 540 microns.

DISTRIBUTION: Recovered from middle part of the type section.

FIGURED SPECIMEN: Pl. 12, fig. 3, slide no. Mega DUN 126-8,
Co-ord. 68.6/112.

Genus ARCELLITES Miner, 1935, emend. Ellis and Tschudy, 1964

- 1935 Arcellites disciformis Miner, Am. Midland Naturalist, Vol. 16, p. 600, pl. 20, figs. 61, 64-66 (type species).
- 1964 Arcellites disciformis Miner, emend. Ellis and Tschudy, Micro-paleont., Vol. 10, p. 75, pl. 1, figs. 1-2, text - fig. 1.

DIAGNOSIS: Megaspores, trilete, spore body spherical with a neck composed of six segments, body of the spore covered with sculptine, appendages present.

HABITAT: The hollow appendages present on the body add buoyancy to the spores, which suggests an aquatic habit. This genus is reported in the deposits of lacustrine or fluvial origin. The genus may

belong to water ferns e.g. Marsileales.

ARCELLITES DISCIFORMIS Miner, emend. Ellis and Tschudy 1964

Plate 13, Figs. 1, 2

1964 Arcellites disciformis Miner, emend. Ellis and Tschudy - Singh, Res. Council Alberta, p. 167, pl. 28, figs. 1-5.

DESCRIPTION: See Singh (1964, p. 167).

SIZE: Av. total length = 700 microns.

Av. equatorial diameter = 325 microns.

Length of appendages = 52 microns.

Width of appendages = 26 microns.

DISTRIBUTION: U. Barremian to Cenomanian. Abundant in the middle part of the type section.

REMARKS: Two varieties of A. disciformis are present in Dunvegan Formation.

TYPE A. The pits on the body are larger in size and spaced at greater than 2 microns (plate 13, fig. 4).

TYPE B. The pits on the body are smaller in size and spaced at less than 2 microns (plate 13, fig. 5).

FIGURED SPECIMEN: Pl. 13, figs. 1, 2, slide no. Mega DUN 126-4 (TYPE A), 126-7 (TYPE B), Co-ord. 45.6/123.3, 61.3/119.

ARCELLITES sp.

Plate 13, Fig. 3

DESCRIPTION: Megaspore, trilete, spore body approximately spherical, with a neck always longer than the diameter of spore body

and composed of six leaf like segments fused by their margins into six ridges running upwards, central part of each segment folded inwards, neck segment slightly twisted, thickness of the leaf-like neck segments broadest at the midline, spore body with a smooth surface, endexine forms a concentric thickened band around the spore body, which may be due to compressional affects, appendages numerous, funnel shaped, broad translucent, apex pitted?

SIZE: Total length = 670 microns.

Equatorial diameter = 260 microns.

Length of neck = 416 microns.

Length of appendages = 104 microns.

Width of appendages = 52 microns.

DISTRIBUTION: Few specimens recovered from the middle part of the type section.

FIGURED SPECIMEN: Pl. 13, fig. 3, slide no. Mega DUN 126-1, Co-ord. 47.1/113.4.

Genus ERLANSONISPORITES Potonie, 1956

1956 Erlansonisporites erlansonii (Miner) Potonie, Beih. Geol. Jahrb. Heft. 23, p. 46-47, pl. 5, fig. 53 (type species).

DIAGNOSIS: Trilete megaspores, trilete mark often covered by reticulation, muri on the reticulum present, often with reticulum transformed into a membranous lamellae, membranous lamellae also developed on exine.

ERLANSONISPORITES RETICULATUS Singh, 1964

Plate 12, Fig. 4

1964 Erlansonisporites reticulatus Singh, 1964, Res. Coun. Alta. Bull. 15, p. 152, pl. 22, figs. 1, 2.

DESCRIPTION: See Singh (1964, p. 152).

SIZE: Equatorial diameter ~ 470 microns.

DISTRIBUTION: Rare, one specimen recovered from the middle part of the type section.

FIGURED SPECIMEN: Pl. 12, fig. 4, slide no. Mega DUN 126-2, Co-ord. 56.6/117.5.

Genus MINERISPORITES Potonie, 1956

1956 Minerisporites mirabilis (Miner) Potonie, Beih. Geol. Jahrb., Heft. 23, p. 67, pl. 9, figs. 87, 88 (type species).

DIAGNOSIS: Trilete megaspores, equatorial outline triangular to round, equatorial zone present, widest at the apices, resulting in a triangular equatorial zona at the apices, reticulate with vesicular lumina and curved muri present.

AFFINITY: Probable affinity is felt with the Family Selaginellaceae.

MINERISPORITES MACRORETICULATUS Singh, 1964

Plate 12, Fig. 5

1964 Minerisporites macroreticulatus Singh, Res. Coun. Alta. Bull. 15, p. 157, pl. 23, figs. 8-11.

DESCRIPTION: See Singh (1964, p. 157).

SIZE: Total equatorial diameter (including zona) - 400 microns.

REMARKS: The reticulum of the central body is slightly indistinct in the central portion of the body.

DISTRIBUTION: Few specimens recorded from the type section.

FIGURED SPECIMEN: Pl. 12, fig. 5, slide no. Mega DUN 126-5, Co-ord. 42/118.

Genus BALMEISPORITES Cookson and Dettmann, 1958

1958 Balmeisporites holodictyus Cookson and Dettmann, Micropaleont. Vol. 4, p. 42, pl. 2, figs. 1-6 (type species).

DIAGNOSIS: Megaspores, spherical body, three equadistant reticulate equatorial outgrowths of the exine; a prominent neck at the proximal pole composed of three united leaf like segments, which surround the tetrad scar.

REMARKS: The spores compared by the genus Balmeisporites were up till now recorded from 70-135 microns. The Canadian specimens are both larger in size with a corresponding increase in the width of reticulum. These size features indicate emendations are needed for the genus Balmeisporites.

BALMEISPORITES GLENELGENSIS Cookson and Dettmann, 1958

Plate 14, Figs. 1, 2

1958 Balmeisporites glenelgensis Cookson and Dettmann, Micropaleont. Vol. 4, p. 43, pl. 2, figs. 9-10.

DESCRIPTION: Megaspore, spore body circular, reticulate,

exine granular, the three segments of the proximal neck short in proportion to the size of the body and broadly attached.

SIZE: 200 microns.

REMARKS: The Canadian specimen of Balmeisporites glenelgensis agree in principle with description of Cookson and Dettmann (1958). The difference is noted in the total length of the megaspore and the wider reticulum present in the Canadian specimen.

DISTRIBUTION: A single specimen was recovered in the middle part of the type section.

FIGURED SPECIMEN: Pl. 14, figs. 1, 2, slide no. Mega DUN 126-2, Co-ord. 49.2/115.9.

SEED COAT

Plate 14, Fig. 3

DESCRIPTION: Elliptical pod, sides convex, tapering, small smooth appendages, exine thick.

SIZE: Total length - 640 microns.

Max. width - 357 microns.

Length of appendage - 50 microns.

Width of appendage at base - 20 microns.

FIGURED SPECIMEN: Pl. 14, fig. 3, slide no. DUN 126-9, Co-ord. 57.2/116.1.

REMARKS: Binda (pers. comm. 1967) reports similar megaflores as Carpothecetes.

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APPENDIX I

SAMPLE PREPARATION AND STUDY

The following steps were employed in the preparation of palynological samples:

First Step

Ten to fifteen grams of sample were broken to grains of 1-4 mm and transferred in polythene bags. Samples were washed twice with distilled water in order to remove surface contamination.

NOTE: From here onwards all steps were followed by centrifuging with distilled water until the sample was neutral. The centrifuge was normally operated at about 1800-2000 r.p.m.

Second Step

For dissolving carbonate content all the samples were treated with 10% hydrochloric acid for two to three hours. This process was repeated if the calcareous content of the sample was high.

Third Step

Hydrofluoric acid (48%) was used for dissolving silicates. A sufficient quantity of acid was used, in order to carry out an efficient digestion of silicates. Normally a period of 24 hours was found sufficient for solubilizing silicates. But a complete maceration in shorter time was reached by boiling the sample in a water bath for about 15 minutes. However, a careful check was taken to avoid violent boiling of the material. It was found essential to cover the polythene beakers with a half open lid. The temperature was regulated carefully, in order to avoid bumping of the material. Some of the silica volatilized as SiF_4 during boiling. The

sample was allowed to cool and subsequently centrifuged to get rid of hydrofluoric acid and clay particles.

Fourth Step

A freshly prepared Schultze's solution (25 c.c. of KClO_3 with 75 c.c. of nitric acid 70%) was used to oxidize the sample. However, a check was made after every ten minutes to avoid over oxidizing the sample. Boiling was found speedier in oxidizing the sample. Care was taken to avoid bumping of the material during boiling. The thumb rule for knowing the completion of oxidation process is marked by the appearance of brown or dark brown color in the sample. However, this was not found true as a rule, particularly for carbonaceous shales, where black colour of the sample dominates throughout the process. Oxidation was followed by brief centrifuging to get rid of the supernatant material.

Fifth Step

The oxidized superfluous organic matter was subsequently solubilized by treating the sample with potassium carbonate (10%) or potassium hydroxide (10%). Both the agents were equally effective in their action. Potassium carbonate or potassium hydroxide can easily dissolve microspores. Therefore no sample was kept in potassium carbonate for more than ten minutes. However, it was found that all of the superfluous matter was not solubilized within ten minutes. However, no attempt was made to prolong the reaction. The sample was washed by centrifuging at different speeds. Long centrifuging at lower speeds was found most effective in removing superfluous matter.

Sixth Step

For the study of megaspore samples were sieved through 149 micron sieve. The material on the sieve was collected and examined for megaspores. Opaque specimens were mounted on well slides and the rest of the specimens were further treated with xylene for five minutes. Xylene was found effective in cleaning the specimen, followed by washing in ethylene alcohol for a few minutes. The specimen was placed on a microscopic slide and mounted in Canada balsam under a cover slip. The slide was dried at low temperature for a few days.

Seventh Step

The samples which passed through 149 micron sieve was suspended in heavy liquid (a mixture of zinc iodide, potassium iodide and cadmium iodide). The heavy liquid (Sp. Grav. = 2.3), neatly separated inorganic and organic matter. The organic matter being lighter than heavy liquid collected at the top and was collected with an eye dropper. The organic matter rich in microspores was diluted with distilled water and centrifuged.

Eighth Step

Two methods were used in staining the microspores. First method was to mix safranin 'O' with the organic residue immediately before mounting. This method resulted in staining red, both the microspore as well as the mounting media. The second method eliminated the staining of media. This was achieved by mixing a few drops of safranin 'O' with the sample. It took 90 seconds to stain the microspores, followed by several washings to remove traces of any excess stain. Thus this process stained the microspores only, which subsequently were mounted.

Ninth Step

Five slides of each sample were prepared, one slide was mounted in corn syrup and the other four slides prepared in elvanol.

For the corn syrup mounting a small portion of the organic residue was placed on a microscopic slide and was thoroughly mixed with a few drops of corn syrup. This was followed by the even distribution of the sample on the slide. The slide was dried under low temperature. This slide was used for studying few microspores in different positions.

For permanent mounting a small amount of residue was mixed with elvanol uniformly and evenly spread on a cover slip. The cover slip was allowed to dry over night. A drop of Canada balsam dissolved with xylol was placed on a slide and the cover slip was carefully placed with the organic smear facing downwards. The slides were dried for 36 hours under low temperature.

Photomicrography

Photomicrographs were taken by an Orthomat Leitz photomicroscope on 1FF 35 mm film. The photographs were printed on Kodak polycontrast F paper. Some of the photographs were taken under oil immersion.

Most of the specimens on the plates are at a magnification of X400 or X500 to give an idea of relative difference in size. Some of the specimens are at a higher magnification, for illustrating finer details.

Examination of Slides

Four to five slides per sample were examined. The frosted

end of the slide was always kept on right hand side. For study lengthwise transverse was taken from right hand to left hand side of the slide. The lengthwise transverse was taken 1 mm apart.

Relative frequency of various species was not counted, because of the study based on a smaller number of samples.

Designation of Slides

All the slides are marked by the alphabet "DUN" which stands for Dunvegan Formation. The first digit denotes the footage at which the sample was collected. The second digit denotes the number of slides.

For example: SLIDE NO: DUN 126-1

DUN = Dunvegan Formation

126 = sample collected 126 feet from the bottom,
at the type section.

1 = slide number one of sample 126.

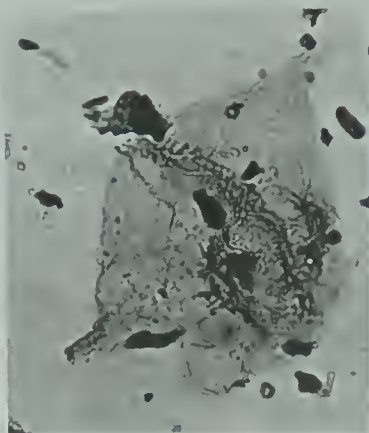
All the slides were deposited in the Repository of the Department of Geology.

EXPLANATION OF PLATE 1

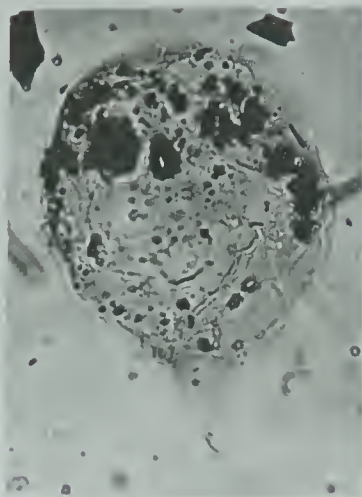
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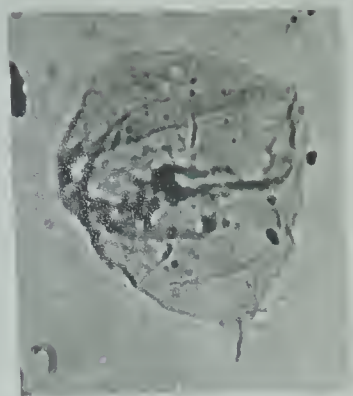
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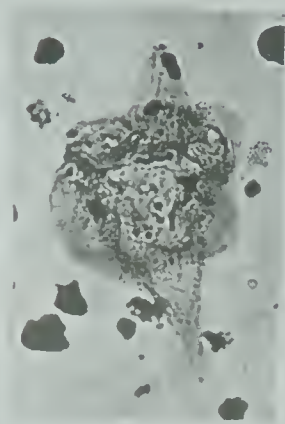
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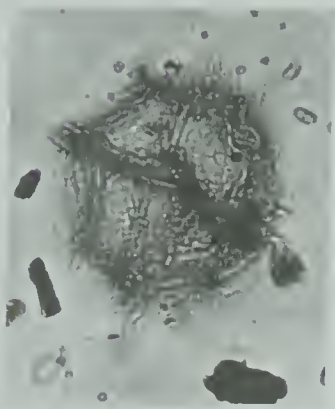
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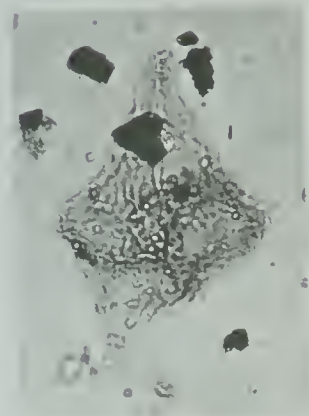
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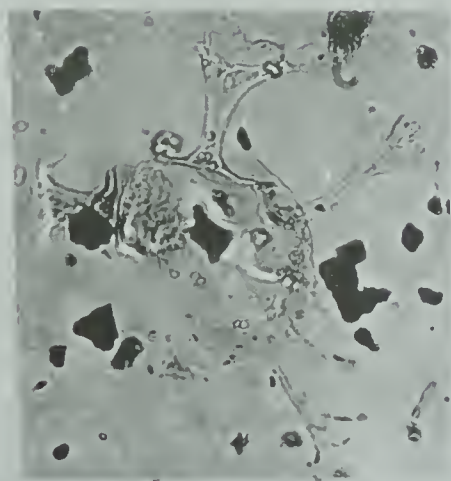
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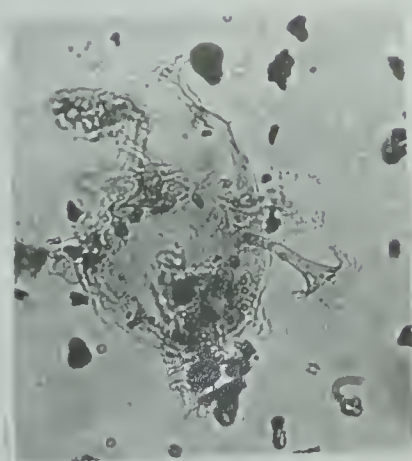
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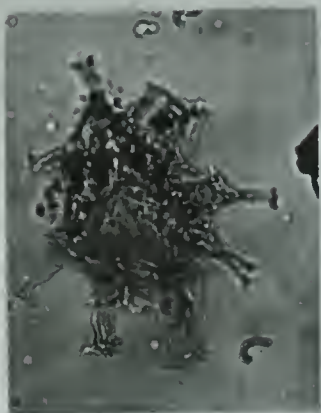
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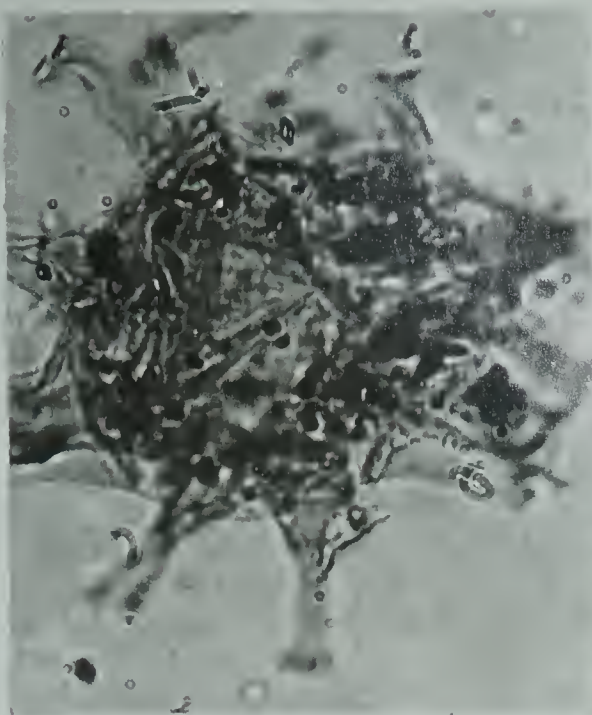
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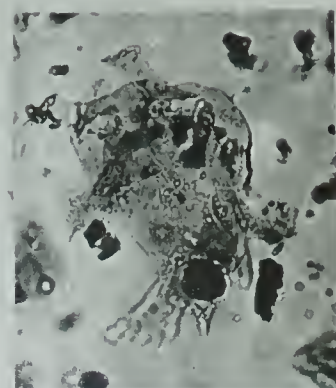
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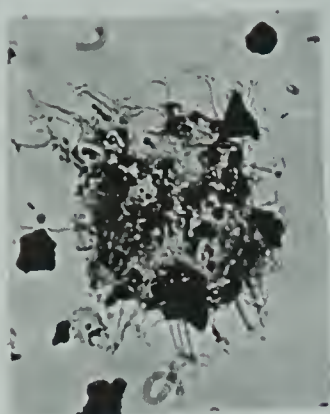
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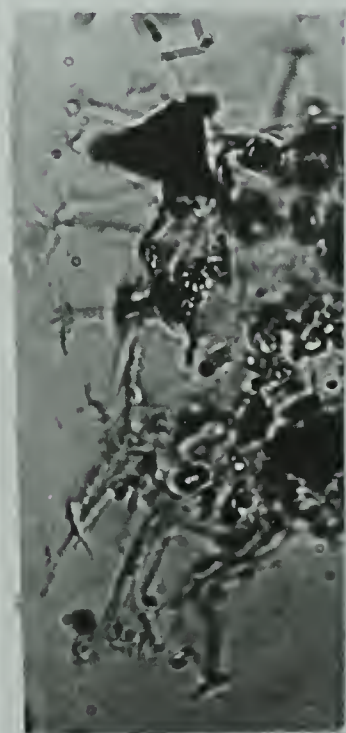
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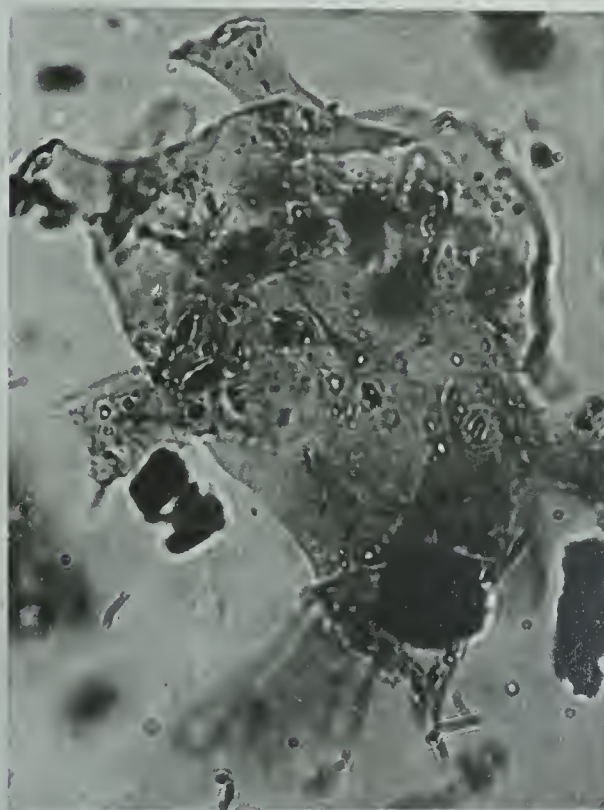
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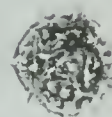
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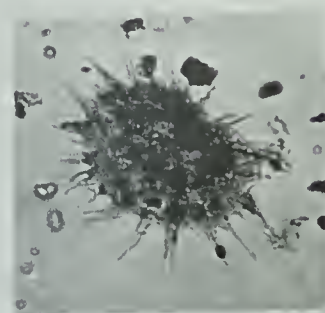
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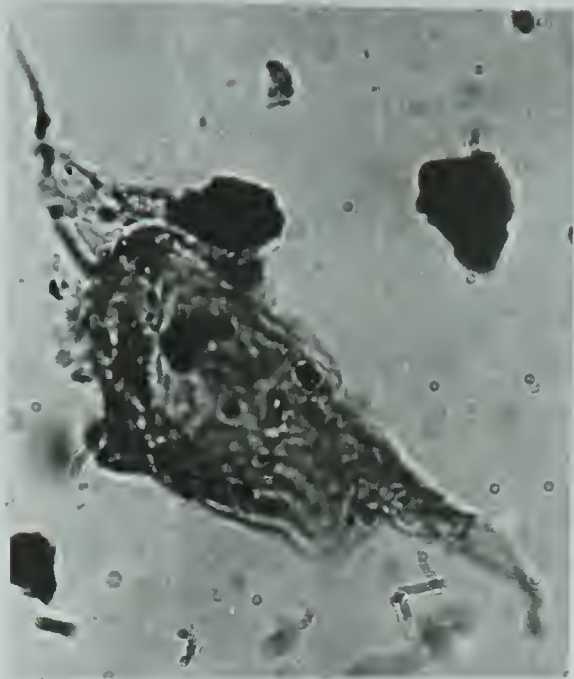
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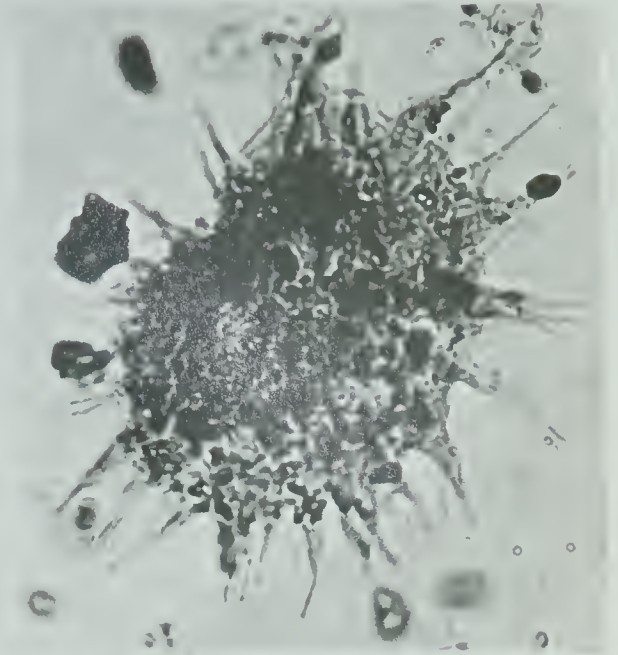
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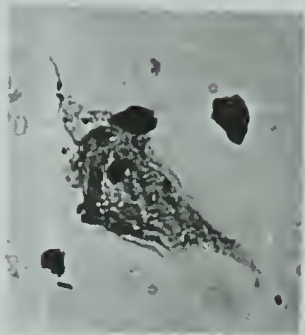
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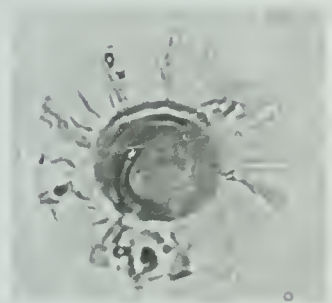
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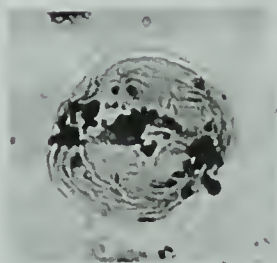
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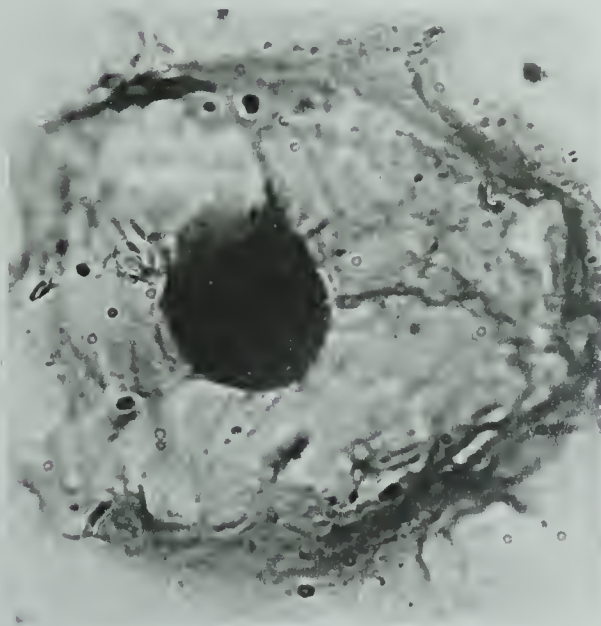
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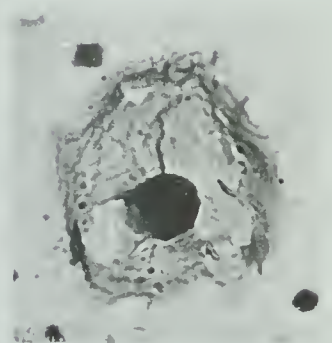
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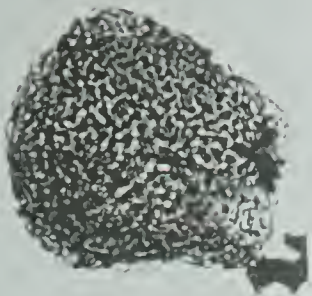
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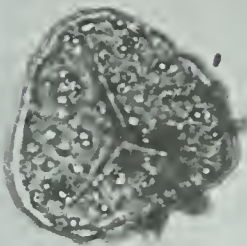
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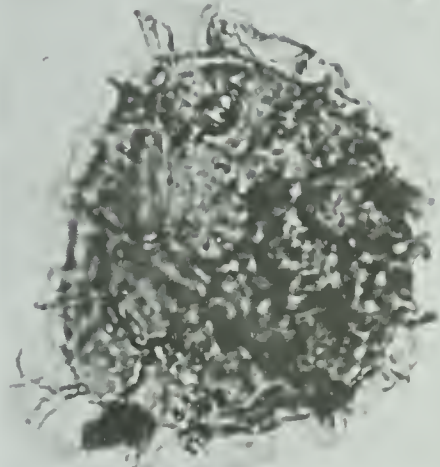
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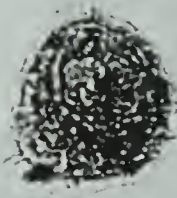
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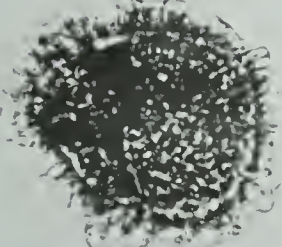
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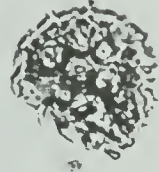
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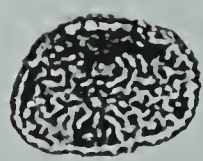
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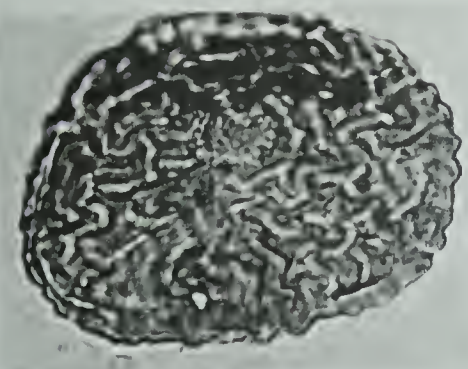
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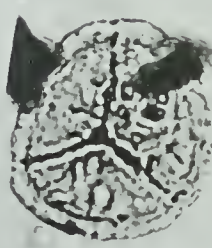
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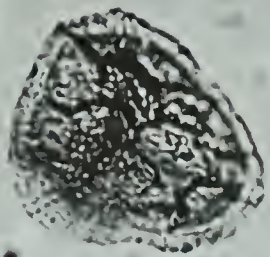
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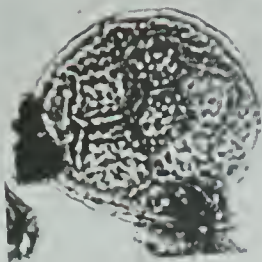
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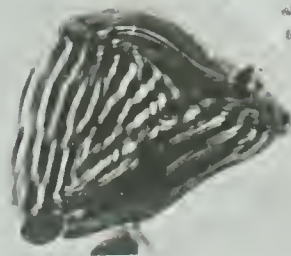
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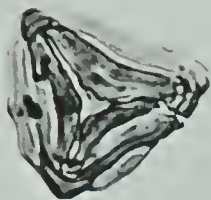
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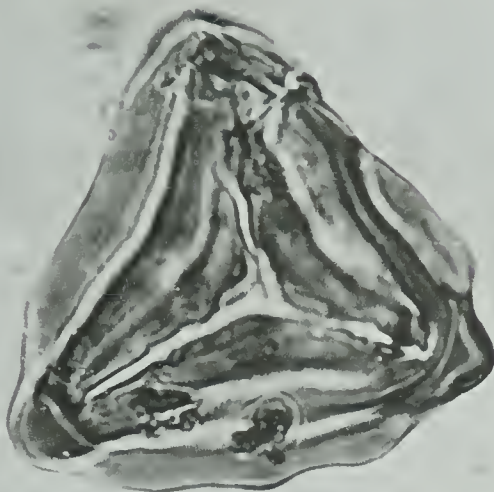
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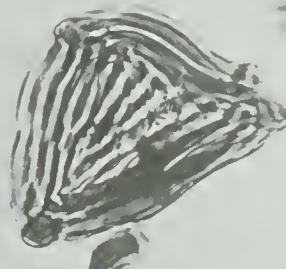
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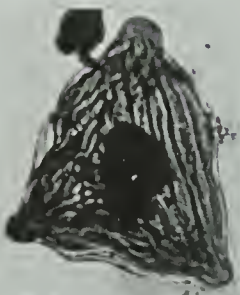
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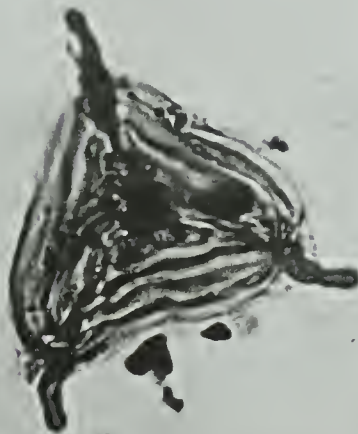
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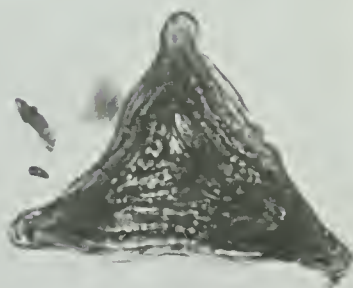
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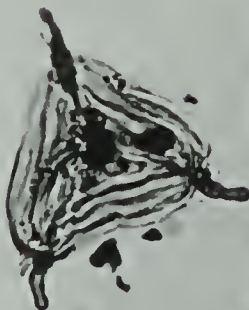
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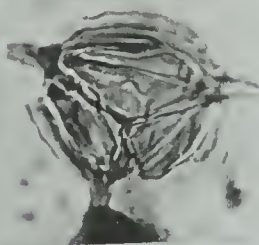
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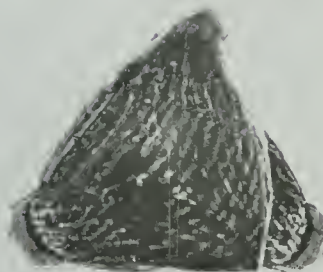
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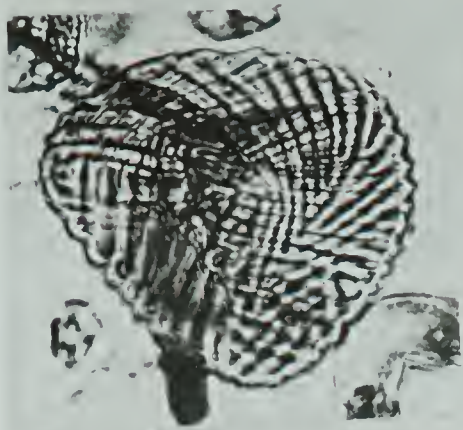
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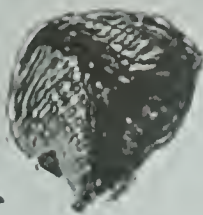
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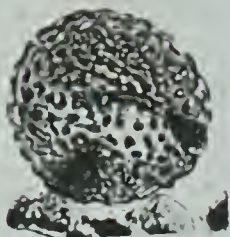
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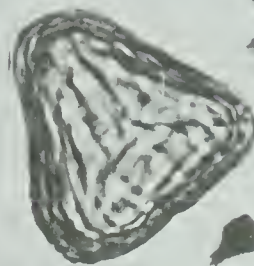
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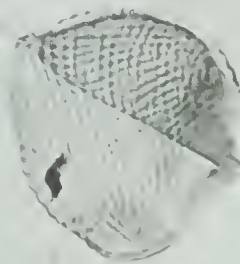
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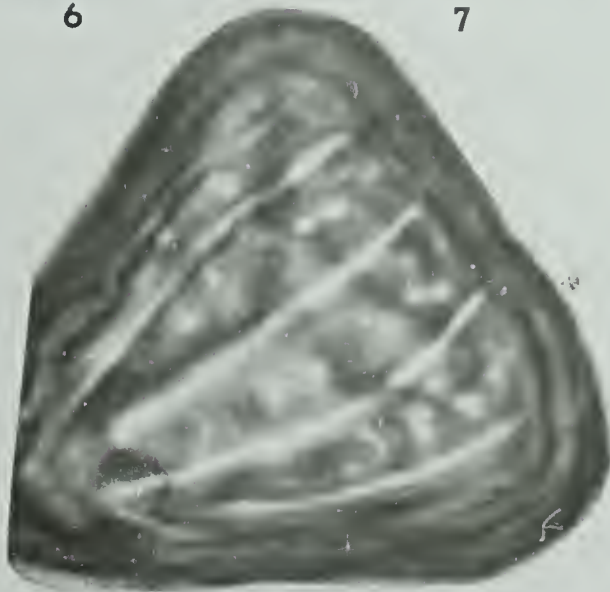
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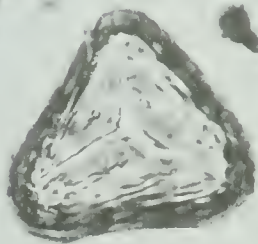
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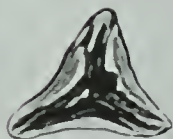
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EXPLANATION OF PLATE 7

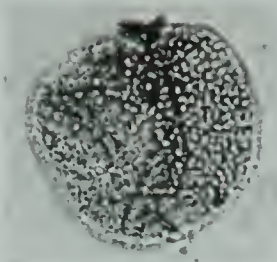
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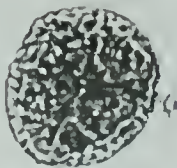
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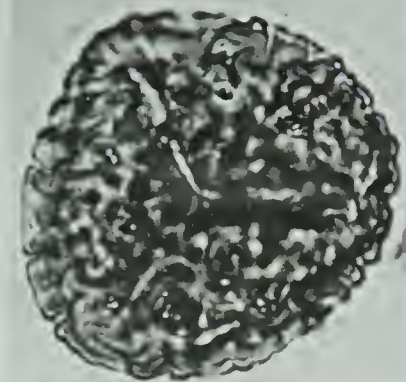
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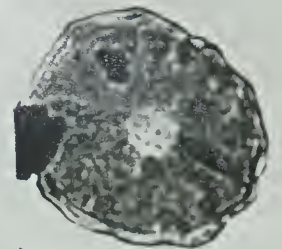
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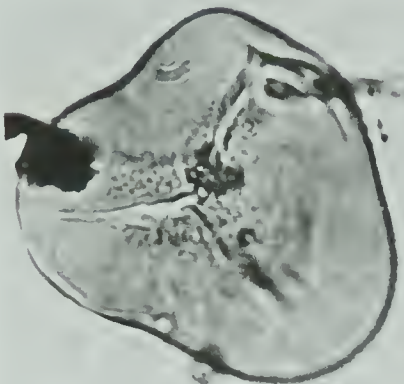
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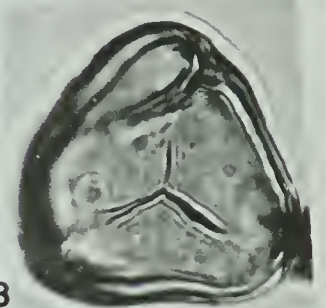
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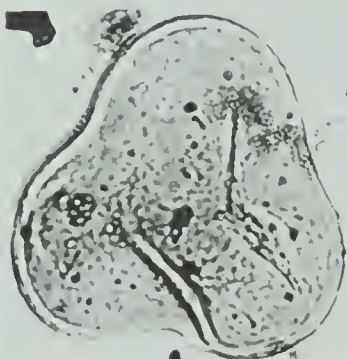
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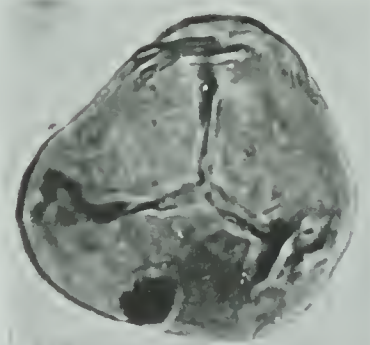
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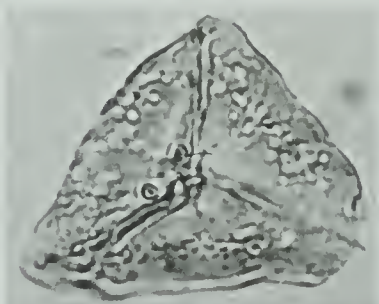
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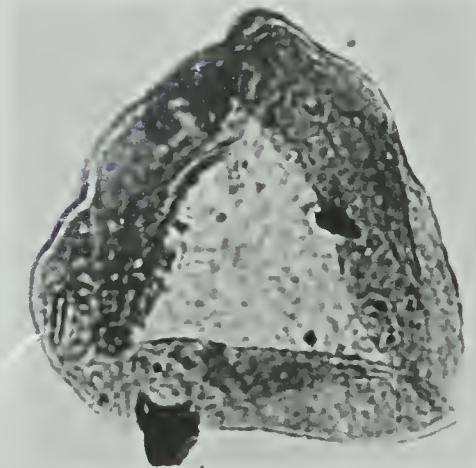
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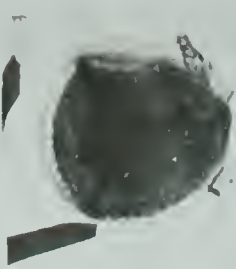
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EXPLANATION OF PLATE 8

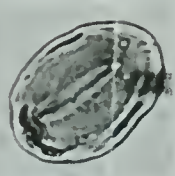
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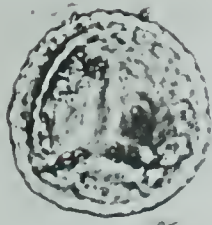
Plate 8



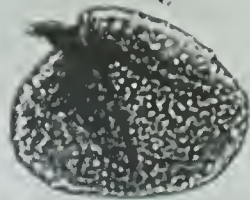
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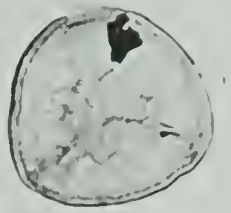
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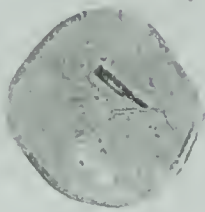
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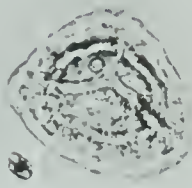
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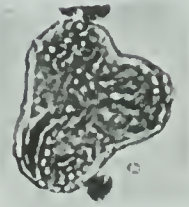
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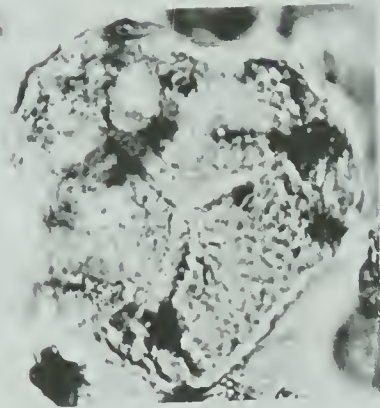
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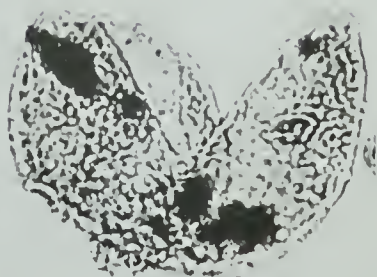
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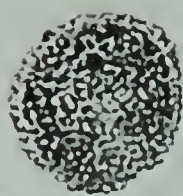


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Plate 10



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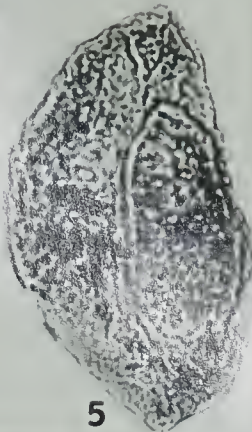
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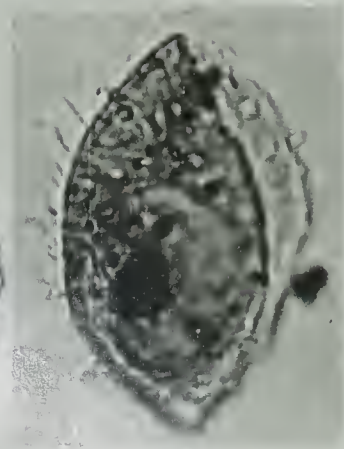
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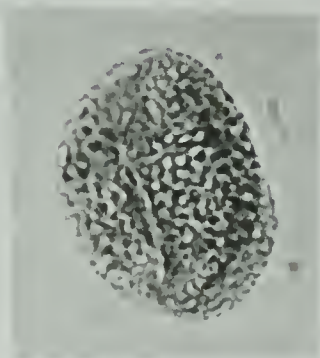
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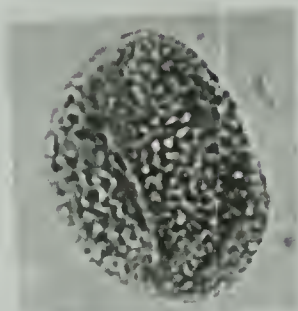
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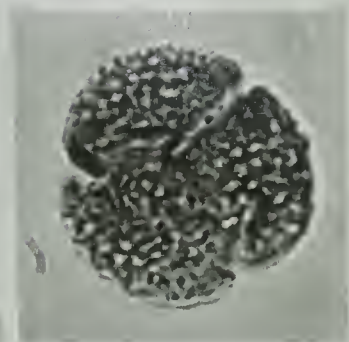
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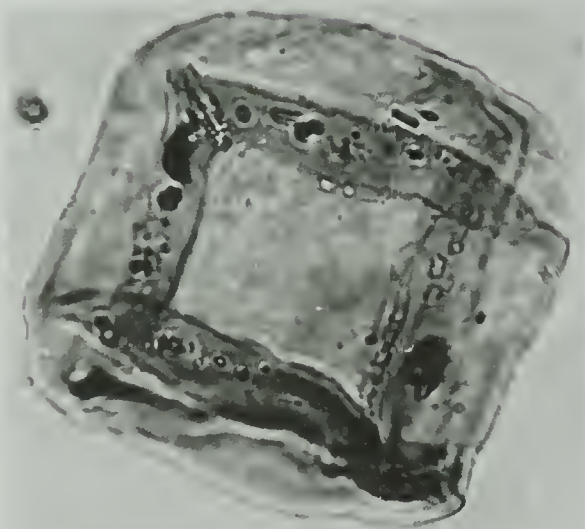
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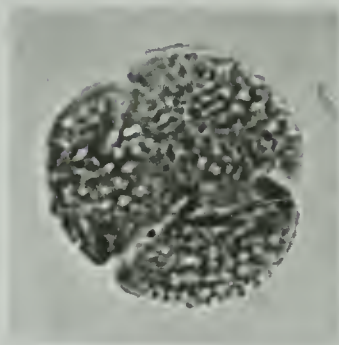
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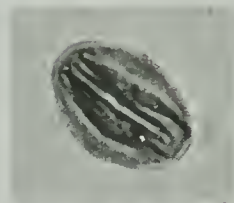
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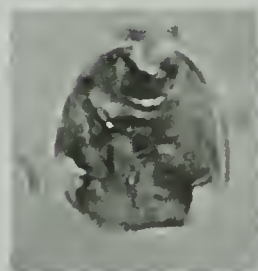
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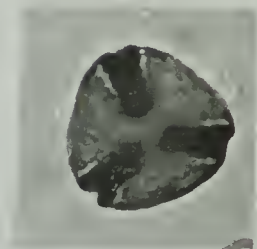
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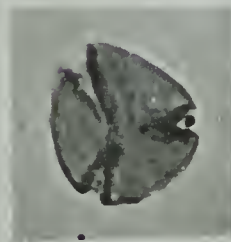
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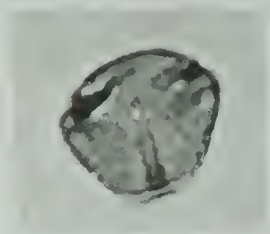
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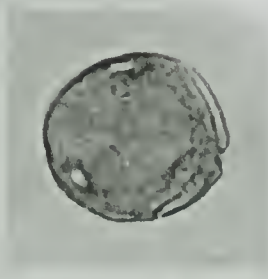
Plate 11



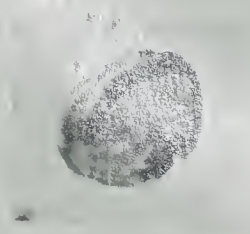
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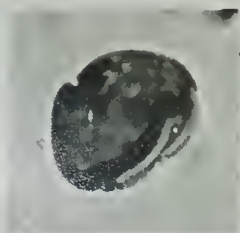
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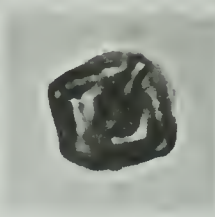
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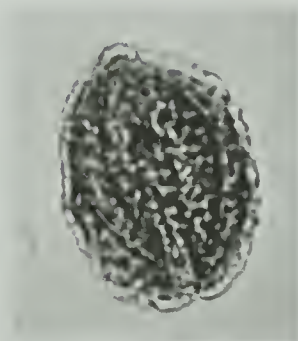
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EXPLANATION OF PLATE 12

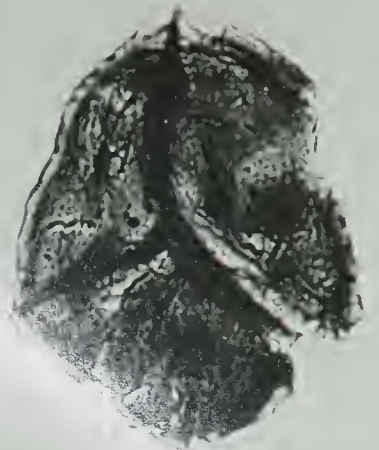
All specimens are illustrated at a magnification of X120 unless otherwise stated.

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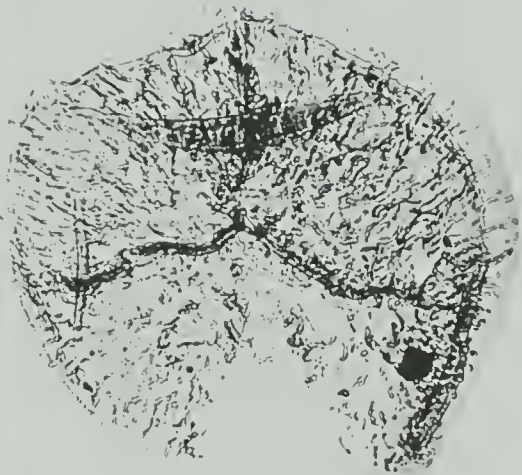
Plate 12



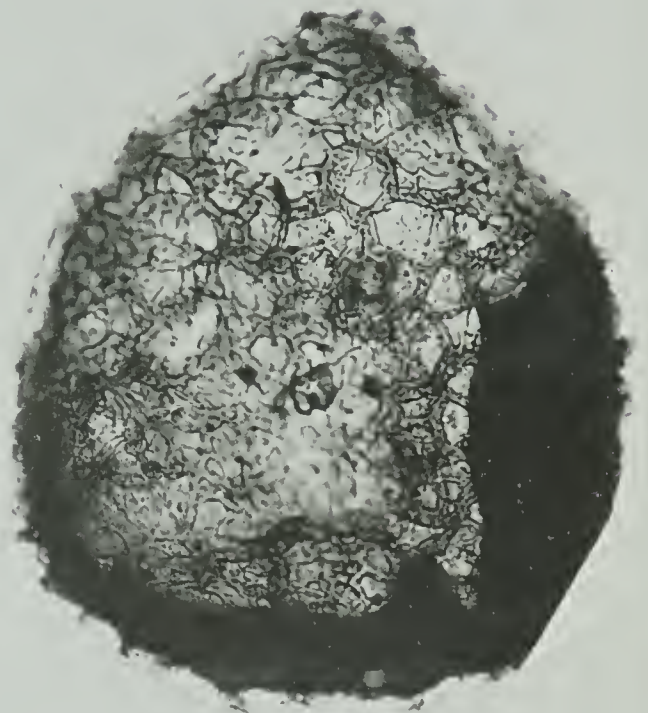
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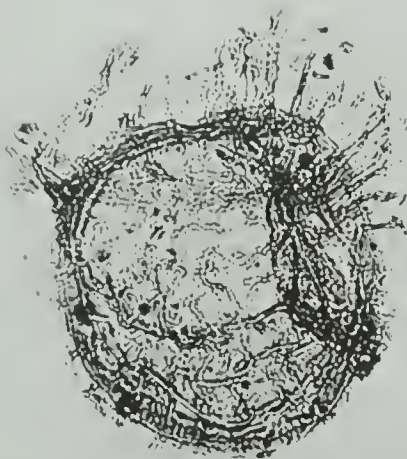
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EXPLANATION OF PLATE 13

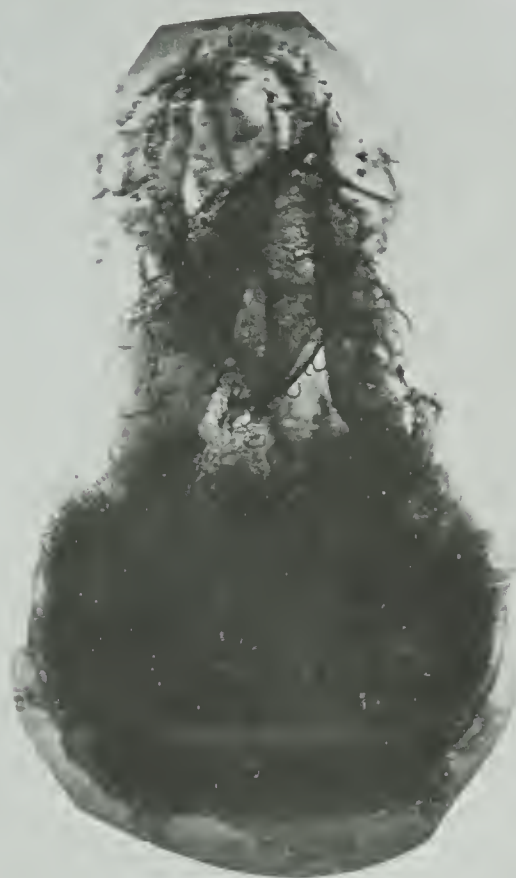
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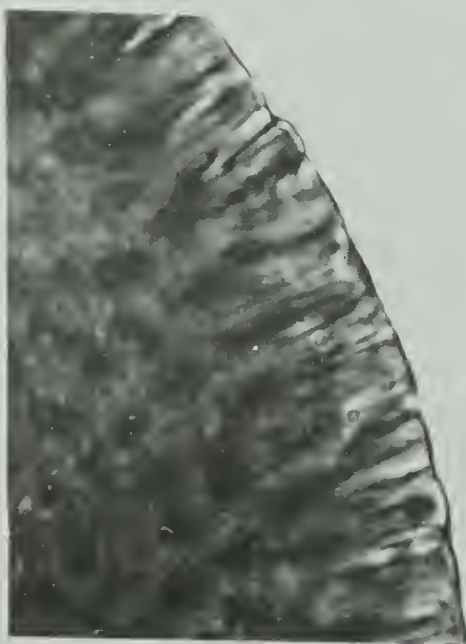
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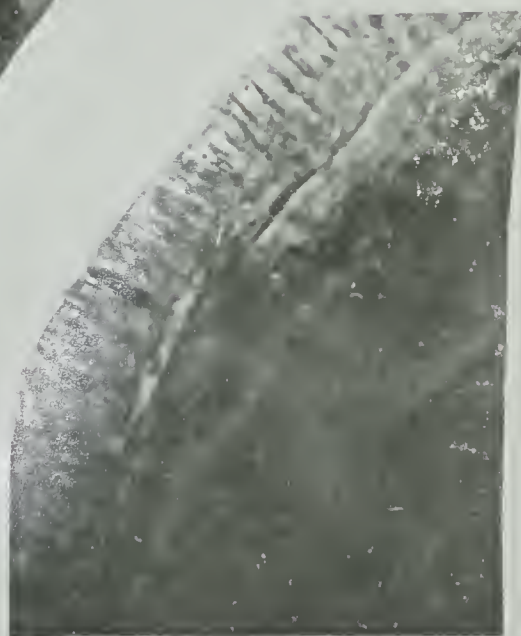
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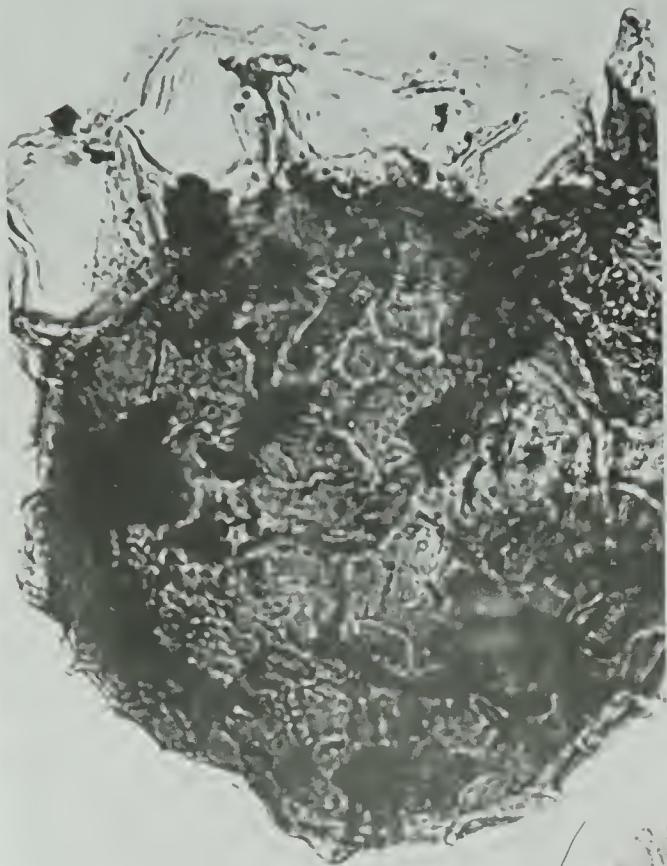


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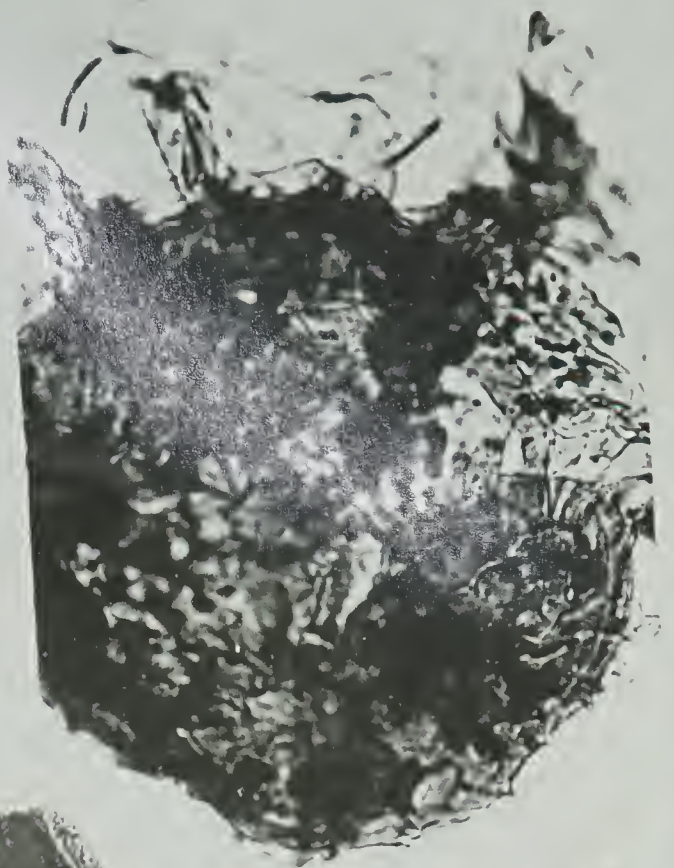
EXPLANATION OF PLATE 14

All specimens are at a magnification of X450 unless otherwise stated.

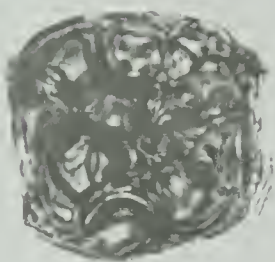
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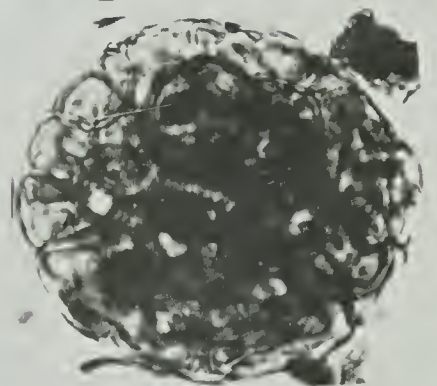
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